MONTHLY WEATHER REVIEW

CLEVELAND ABBE, Editor.

VOL. 42, No. 2
W. B. No. 528

FEBRUARY, 1914

CLOSED MARCH 28, 1914
ISSUED APRIL 30, 1914

INTRODUCTION.

During the summer of 1913 the Secretary of Agriculture established a board to reorganize the system of publications of the Department of Agriculture. In accordance with the proceedings of the board and the suggestions from representatives of the Weather Bureau, the "Bulletin of the Mount Weather Observatory" ceased to be published with the completion of its volume 6. Any subsequent contributions from the members of the research staff that would have been proper for that Bulletin will be incorporated in the Monthly Weather Review. The climatological service of the Weather Bureau will be maintained in all its essential features, but its publications, so far as they relate to purely local conditions, will be incorporated in the monthly reports for the respective States, Territories, and colonies.

Beginning with January, 1914, the material for the Monthly Weather Review will be prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 6.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials will prepare the six sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that have during recent years been prepared by the 12 respective "district editors" will be omitted from the Monthly Weather Review, but will in future be collected and published by States at selected section centers.

The data needed in section 6 can only be collected and prepared several weeks after the close of the month whose name appears on the title page; hence the Review as a whole can only issue from the press within about eight weeks from the end of that month.

The Annual Summary of the Review will hereafter appear as an Annual Supplement containing the essential tables heretofore published in the annual Report of the Chief of the Weather Bureau.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the following directors and superintendents:

The Meteorological Service of the Dominion of Canada.
The Central Meteorological and Magnetic Observatory of Mexico.
The Director General of Mexican Telegraphs.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, St. Petersburg.
The Philippine Weather Bureau.
The General Superintendent United States Life-Saving Service.

SECTION I.—AEROLOGY.

THE TWILIGHT COLORING OF 1913.

The years 1912 and 1913 were notable in the history of our globe for several violent volcanic eruptions of the explosive type. The eruption of Katmai in Alaska in 1912 and its attendant meteorological phenomena has already been treated in the Monthly Weather Review for 1913, volume 41, page 153, and in the Mount Weather Bulletin, volumes 5 and 6. The eruption of Asama-Yama, Japan, on June 17, 1913, and of Sakura-Shima on January 11–12, 1914, have not yet been discussed here. It is possible that we shall not be able to discriminate between the effects due to the one and to the other of these three eruptions. In the first of the following notes Prof. Ignazio Galli describes the noteworthy twilight colorings observed by him at Rome during 1913. These he ascribes to the dust cloud from the Asama-Yama eruption. The second note by Prof. Kimball presents observations at Mount Weather for the same period; but he is not yet prepared to assign the phenomena to any definite eruption.

ITALIAN TWILIGHTS OF 1913.[1]

By Prof. IGNAZIO GALLI.

[Dated Rome, Dec. 14, 1913.]

At 20h. 04m. [8:04 p. m.] July 13, 1913, I noticed that the northwestern sky was tinted a beautiful orange color with an extended base, later I saw the coloring increasing in intensity and becoming almost red toward the horizon. On the next day the same phenomena was repeated, but more weakly; on the evening of the 15th it returned with about the intensity that marked the glow of the 13th; and from the 16th to the 18th the intensity again diminished. On the evening of July 19, however, the atmospheric coloring at Rome was so splendid as to recall the celebrated twilights of the winter of 1883-84. On this date I wrote a letter published July 21-22, 1913, in the "Piccolo Giornale d'Italia," No. 202. For five months the phenomenon has continued with frequent variations in intensity, and only yesterday, December 13, it was very beautiful.

After July 19 the more vivid colorings appeared on the evenings of July 29, August 22, September 2, 5, 24, and 25, October 9 (through the clouds), and on November 29. On at least 24 other evenings the coloring was still very beautiful, a little later it was but moderate, and on occasions became weak or was almost absent.

In general, a few minutes after sunset the atmosphere about the horizon acquires a very strong white color which passes into a yellowish, and then into a decided yellow, into an orange hue, and finally turns to a more or less deep red. The yellow tint ordinarily begins 10 or 12 minutes after sunset, or a little earlier if the coloration is to become very beautiful.

The maximum height of 50 or 60 degrees, and sometimes even more, is almost always observed at the appearance of the yellow tint, with a horizontal extent of at least 90 degrees. The greatest height endures for a couple of minutes, sometimes even four or five minutes, after which the glow slowly (a rapid rate is rare) shrinks until there remains but a great red zone along the horizon. This belt gradually dissolves, and after a few minutes disappears. The slow variations in color make it impossible to ascertain the exact moments of their beginnings and endings. I may state, however, that the average duration of the whole phenomenon from the yellow to the extinction of the red, varies between 20 and 25 minutes, while the most beautiful appearances lasted from 30 to 35 minutes.

After the entire disappearance of the red light a large area of the western sky remains a bright whitish or a rose color for another 40 to 50 minutes. Not rarely the sky just above the red zone on the horizon takes on a green color clearly distinguishable from the dark blue of the remainder of the vault. It may be thought that the ocular impression of a green is only a physiological phenomenon due to the contrast with the red of the lower band, and in the greater number of cases this is probably the fact. But it is quite certain that sometimes the green color of the sky persists for 15, even 20, minutes after the entire disappearance of the red band. I have also observed this same phenomenon during other periods of vividly colored twilights.

. . . Although unfavorably situated since mid-October for observing the morning twilight, I have at times been in the open at about a half hour before sunrise, and I have always seen a more or less vivid rosy or orange coloring in the east, as might have been predicted. . . .

[1] Extracted and translated from a reprint of his paper in Atti, Pontif. acc. Romana dei Nuovi Lincei, anno 67, Dec. 14, 1913.

TWILIGHT COLORS AT MOUNT WEATHER, VA., IN 1913.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated Mount Weather, Va., Mar. 14, 1914.]

Early in August, 1913, the brilliancy of twilight colors both morning and evening attracted the attention of the observers at Mount Weather, Va. The colors reached a maximum brilliancy in September, but did not diminish noticeably until December. The following description of sunset colors for September 9, 1913, is characteristic of the twilight colors throughout this period:

Sun set about 6:30 p. m., seventy-fifth meridian time. The western horizon was then a brilliant orange, which increased in brilliancy until about 10 minutes after sunset, when a pink, or rose-colored glow appeared, extending from about 10° to 30° above the horizon, and for about 20° on each side of a vertical circle through the sun. This glow increased in brilliancy until about 20 minutes after sunset, and then gradually faded, disappearing about 30 minutes after sunset.

By this time the sky on the horizon for at least 60° on each side of the point of sunset was a brilliant red, shading off into bright yellow above, the latter color extending to a height of about 30°. At 7 p. m. the eastern sky was yellow, apparently on account of reflection from the western sky. The red on the western

horizon lasted until 7:30 p. m., when it was gradually replaced by yellow. The latter color was bright on the horizon until 7:40 p. m., and was barely visible at 7:50 p. m.—1 hour and 20 minutes after sunset. On some nights the twilight glow was visible for fully an hour and a half after sunset.

RECENT BALLOON EXPERIMENTS.[1]

C. G. ABBOTT, Astrophysical Observatory.

Notwithstanding the satisfactory state of the theory of solar constant measurements by the method of Langley, depending upon spectro-bolometric observations at high and low sun combined with measurements by the pyrheliometer, and notwithstanding the close agreement between results obtained by this method for many years at stations of differing altitude from sea level to 4,420 meters elevation, there still exists the possibility that if we could, indeed, go outside the atmosphere altogether, we should obtain values differing materially from those given above. So long as we observe at the earth's surface, no matter how high the mountain top on which we stand, the atmosphere remains above us, and some estimate must be made of its transmission before the solar constant can be determined. Different persons will differ in the degree of confidence which they will ascribe to measurements of the atmospheric transmission such as have been considered, and there are still some who totally disbelieve in the accuracy of the results thus far obtained, even though they be confirmed by observations at such differing altitudes. Accordingly it has seemed highly desirable to check the results by a method of direct observation by the pyrheliometer, attaching the instrument for this purpose to a balloon and sending it to the very highest possible altitudes. By a coöperation between the Smithsonian Institution and the United States Weather Bureau, experiments for this purpose were made in July and August of the year 1913.

The instruments were modified in form from the silver disk pyrheliometer, which has been described above. As the apparatus could not be pointed at the sun, the disk was placed horizontally, and the thermometer was contrived to record its temperature by photography upon a moving drum. The receiving disk was alternately exposed to the sun and shaded by the intervention of a shutter, operated intermittently by the clockwork which rotated the drum under the stem of the thermometer. Five instruments of this kind were sent up on successive days. While it was well known that the temperature of the higher air would go as low as $-55°$ C., it was believed that a blackened disk, exposed half the time to the direct sun rays, would certainly remain above the temperature of $-40°$, which is the freezing point of mercury. This expectation was disappointed. Accordingly, owing to the freezing of the mercury in the thermometer, the highest solar radiation records obtained during the expedition were at the altitude of 13,000 meters, although the balloons in some instances reached the altitude of 33,000 meters.

The results obtained, while they have not the same degree of accuracy as those obtained by direct reading of the silver disk pyrheliometer, are yet of considerable weight. All the measurements unite in indicating values of the solar radiation at altitudes of 10,000 meters and higher, which fall below the value of the solar constant of radiation as obtained by other methods, and above the value of the radiation at the summit of Mount Whitney as obtained by different observers with pyrheliometers. It is expected in the coming year to repeat the observations with balloons under much improved circumstances. By aid of electrical heating apparatus it is expected to keep the surroundings of the disks at approximately the freezing temperature, even though exposed to the air at temperatures as low as $-55°$ C. In this way it is hoped to obtain good pyrheliometer measurements as high as it is possible for sounding balloons to go, and possibly to an altitude of 40,000 meters. As the atmospheric pressure at such altitudes is less than 1 per cent of that prevailing at sea level, the experiments, if successful, may be expected to remove reasonable doubt of the value of the solar constant of radiation.

[1] [Extracted from "The solar constant of radiation." Journal of the Washington Academy of Sciences, Washington, Mar. 4, 1914, v. 4, No. 5.]

SECTION II.—GENERAL METEOROLOGY.

THE EFFECT OF WEATHER UPON THE YIELD OF CORN.

By J. WARREN SMITH, Professor of Meteorology.

[Dated Weather Bureau, Columbus, Ohio, Jan. 5, 1914.]

INTRODUCTION.

The geographical distribution of vegetation is determined by the climate, and the principal climatic factors that must be considered in the development of plants in any part of the country are temperature, rainfall, and sunshine.

Temperature is the most important factor in determining the broad climatic belts within which different plants will grow and mature, as well as the more narrow belts where they will make their best development.

Investigation has shown that every plant has its optimum temperature and moisture values during which it makes its best development, and that this varies in different periods of its growth. And not only this, but the heat and moisture must be in right proportion.

The moisture in the soil carries the plant food to the roots to be worked into vegetable tissue by the energy of the solar rays. If there is not enough material brought to the plant then the solar energy is wasted, and on the other hand if the heat is not sufficient to use up the material brought by the moisture then the material is wasted.

In the highest altitudes there is an excess of moisture and a deficiency of heat. These are the conditions that obtain in most of Europe, and in these countries the crop yields are determined largely by the temperature.

In other places where the rainfall is sufficient and the temperature too low for the best growth of plants, such as in Alaska, the sunshine becomes the most important factor.

No plant life is perfected and reaches its fullest maturity except through the influence of the short waves of solar energy which we call light. Dark rays or heat can not replace sunlight in the growth of vegetation, but sunlight can partially replace heat. Barley and oats and similar crops can be cultivated, as they are, as far north as 70° latitude only because of the quantity of light.

A value called the "sunshine-hour degree" may be obtained by multiplying the average daily heat necessary to grow and mature a crop by the total possible number of hours of sunshine from planting to harvesting.

If this is done for corn in the United States the sunshine-hour degrees from the date of planting to the date of harvesting of corn for the district between latitude 30° and latitude 35° are found to be 80,313; between latitudes 35° and 40°, they are 65,778; and they amount to 47,887 between latitudes 40° and 45°; thus showing that the number of sunshine-hour degrees necessary to make a crop diminish as the latitude increases, and explaining further why there is a decided difference in the quantity of heat necessary for the same crop at different latitudes due to the difference in the quantity of light.

RAINFALL MOST IMPORTANT IN THIS LATITUDE.

In places where the temperature and sunshine are generally sufficient the development of the plant and more especially the crop yield depends most largely upon the rainfall. This is particularly true in most of the western part of the United States and to a large extent in central and eastern districts as well.

It has been demonstrated by long experiments in most of the temperate region that the yield of both grain and straw are greatest when the soil contains from 40 to 80 per cent of its full water capacity during the most active season of growth.

The most advantageous percentage of moisture varies with different plants, depending upon their method of using the water. In general the quantity of water necessary for a maximum crop increases with the richness of the soil, the closeness of the stand of plants, the size of the leaves, the dryness of the air, the velocity of the wind, and the temperature.

One writer states that it takes 350 tons of water to mature one acre of corn. Another, that unmulched land loses 200 barrels of water per acre each day by evaporation.

The grain plant obtains a great part of its total weight from the soil during the early part of its growth, and a lack of moisture at this time will cause a short straw but not necessarily a small yield of grain. During the latter part of the growth the seed is being made chiefly from material stored in the stalk, and moisture must be present to flush the material from the stalk into the head or the grain will be shrunken.

CRITICAL PERIODS OF GROWTH.

A careful study of the work of others as well as personal investigation leads the writer to the conclusion that all plants have a certain critical period when favorable weather will produce a good crop and unfavorable weather a poor crop. Also that it is quite possible to determine the most critical period as well as the weather element most affecting the conditions by a detailed study of the results in the field from the records of previous years.

In some crops this critical period is very short. In some, temperature seems to be the most important weather factor and in others it is the rainfall. In some crops the period seems to be soon after seeding and in others while in blossom. In apples, for example, our studies indicate that the weather during the formation of the fruit buds more than a year before the crop is harvested, has a greater effect upon the yield than that of any like period between these dates.

It seems to the writer that when the critical period for a crop has been determined, together with the meteorological factor most affecting it, and then the climate of a place calculated, the adaptability of that crop to that particular place can very quickly be determined. In some cases it will be possible to vary the variety, time of seeding, fertilizing (potassium nitrate hastens ripening),

or cultivation, so as to bring the critical period into the time when most favorable weather conditions are most apt to prevail. In other cases it will be found best to substitute some other crop that will lend itself to these conditions. The one crop will do fairly well part of the time, while the other crop will reach its maximum most of the time.

Further, we believe that this critical period in most instances is long enough before the date of harvest to allow for giving more attention to other crops which perhaps may be substituted. For example, there is no question but the rainfall for May is the most important factor in the hay crop in most of the northern part of the United States. If, therefore, it is found toward the latter part of this month that the rainfall has been light, other forage crops may be planted to take the place of the small hay crop.

The critical period in the growth of corn.—The writer has devoted considerable time during the past 10 years to the problem of ascertaining just what effect the different weather factors have on the different crops and in trying to find the critical periods. A large amount of data has been brought together and some interesting and important results obtained.

As nearly 75 per cent of the world's production of corn is grown in the United States, and as the economic importance of this crop is so great, it has been thought best to prepare for publication the following discussion of the effect of weather upon corn.

It is not intended to be a complete or final study of the problem, because even as we are completing the paper we are constantly finding new problems and new lines of research which demand further attention. We believe it will show the methods used, however, and help to point out the most critical period in the growth of this important crop and the kind of weather that most affects the final yield.

JULY RAINFALL AND CORN YIELD IN OHIO.

In the Yearbook of the United States Department of Agriculture for 1903, page 215, the writer gave a short article upon the relation of precipitation to the yield of corn. The yield in each of the eight large corn-producing States in the central part of the country was compared with the rainfall during June, July, and August by means of curves.

The most important fact brought out in this article was the close relation between the rainfall for the month of July alone and the yield of corn. The yield curve for the eight States compared almost as closely with the rainfall curve for July alone as it did with the rainfall curve for the three months combined or with any two of them. The period coverd was from 1888 to 1902, inclusive.

A correlation method.—While the curve method of showing a relation between two factors is the most graphic, it is not the most accurate. Hence in Table 1 we have compared the average rainfall for the month of July for Ohio with the average yield of corn for the whole State for a period of 60 years by the simplest form of the correlation table.

As this form of correlation has been used very freely throughout this paper and as it may not be familiar to all of its readers the method will be explained in detail in discussing Table 1. (See also Monthly Weather Review, 1911, v. 39, p. 792.)

Eight columns are used in the table. Column 1 indicates the items, which in this case are the years from 1854 to 1913, inclusive, a period of 60 years.

Column 2 gives the average rainfall for the State of Ohio for the month of July for each of these years. Column 3 shows the departure of the rainfall for each year, from the average or normal for the month. In column 4 these departures from the normal have simply been squared.

In column 5 there has been entered the average yield of corn for the State of Ohio for each year, in bushels per acre. Column 6 gives the difference between the yield for each year and the normal or average for a long period.

The average yield of corn for Ohio for the 60 years is 34.5 bushels per acre. A careful inspection of the yield figures, however, will show a gradual increase in the yield during much of the time, and instead of taking the difference between the yield for each year and the average for the whole period it seemed best to use the mean for each 20 years in determining the departure figures for column 6. The average yield of corn for the period from 1854 to 1873 was 32.9 bushels per acre; from 1874 to 1893, 33.5 bushels per acre; and from 1894 to 1913, 37 bushels per acre. Inasmuch as a mean yield was determined for each 20 years in showing the departure from the normal the rainfall departures in column 3 were obtained for the same years in the same manner. It will be noticed also that the yield figures are given to tenths while the departure figures are to the nearest whole number.

The figures in column 7 are the square of the departure figures in column 6 and correspond with column 4.

In column 8 there is given the product of the two departure columns 3 and 6. Care must be taken in this column to place the proper sign before the figures, remembering that in multiplying like signs produce "plus" and unlike signs "minus" values.

The next step in the calculation is to obtain the sums of columns 4 and 7, multiply them together and obtain the square root of the product. The sum of column 4 is 111.83 and of column 7, 1,045. The product of these factors is 116,862.35 and the square root of this product is 341.8.

The next step is to obtain the algebraic sum of the values in column 8. This is +203.2 and this must be divided by 341.8 the square root of the product of the sums of columns 4 and 7. This gives a quotient of +0.59 which is called the "*correlation coefficient*" or r.

In this method of correlation if there is an *exact* relation between the two factors under discussion the correlation coefficient will be either +1 or −1. That is to say, if every time the rainfall was increased a certain amount the yield of corn was increased in exactly the same ratio then the correlation coefficient would be exactly +1. And on the other hand if every time the rainfall was increased a certain definite amount the corn yield would be *decreased* in an exact ratio the correlation coefficient would be exactly −1.

So in this correlation, the nearer the correlation coefficient, r, approaches 1 the closer the relation, and the nearer it approaches 0 the less the relation. Some writers believe that the relation or influence of one factor upon another is well established if the correlation coefficient is three times the probable error, while others think that it should be six times the probable error. It probably is safest to assume that there may be some relation if the correlation coefficient is three times the probable error and that the relation is established beyond question if it is more than six times the probable error.

The probable error is found by the following equation in which r is the correlation coefficient and n the number of years under consideration.

$$0.674\frac{1-r^2}{\sqrt{n}}$$

Substituting the values obtained in Table 1 we have the equation:

$$0.674\frac{1-(0.59)^2}{\sqrt{60}}$$

which equals ± 0.057 which is only $\frac{1}{10}$ of the correlation coefficient. This shows without question a very high correlation between the July rainfall and the yield of corn in Ohio covering a 60-years record.

TABLE 1.—*Correlation of July rainfall, and the yield of corn in Ohio, 1854 to 1913.*

Year.	July rainfall.			Corn yield.			3×6
1	2	3	4	5	6	7	8
	Amount.	Departure.	Square of departure.	Amount.	Departure.	Square of departure.	
	Inches.	*Inches.*		*Bushels.*	*Bushels.*		
1854	2.6	−1.5	2.25	26.0	−7	49	+10.5
1855	5.8	+1.7	2.89	39.7	+7	49	+11.9
1856	2.6	−1.5	2.25	27.7	−5	25	+ 7.5
1857	4.9	+0.8	.64	36.6	+4	16	+ 3.2
1858	4.7	+0.6	.36	27.7	−5	25	− 3.0
1859	1.6	−2.5	6.25	29.5	−3	9	+ 7.5
1860	5.8	+1.7	2.89	38.2	+5	25	+ 8.5
1861	3.3	−0.8	.64	33.5	+0.4	....	− 0.3
1862	3.6	−0.5	.25	30.0	−3	9	+ 1.5
1863	2.6	−1.5	2.25	27.0	−6	36	+ 9.0
1864	2.1	−2.0	4.00	27.0	−6	36	+12.0
1865	5.7	+1.6	2.56	35.0	+2	4	+ 3.2
1866	5.1	+1.0	1.00	36.5	+4	16	+ 4.0
1867	3.2	−0.9	.81	29.8	−3	9	+ 2.7
1868	2.7	−1.4	1.96	34.4	+2	4	− 2.8
1869	4.8	+0.7	.49	28.4	−4	16	− 2.8
1870	4.7	+0.6	.36	37.5	+5	25	+ 3.0
1871	3.7	−0.4	.16	36.7	+4	16	− 1.6
1872	6.7	+2.6	6.76	40.9	+8	64	+20.8
1873	6.2	+2.1	4.41	35.1	+2	4	+ 4.2
1874	3.8	−0.1	.01	39.2	+6	36	− 0.6
1875	6.9	+3.0	9.00	34.2	+1	1	+ 3.0
1876	6.4	+2.5	6.25	36.9	+3	9	+ 7.5
1877	3.7	−0.2	.04	32.5	−1	1	+ 0.2
1878	5.4	+1.5	2.25	37.8	+4	16	+ 6.0
1879	4.2	+0.3	.09	34.3	+1	1	+ 0.3
1880	4.2	+0.3	.09	38.9	+5	25	+ 1.5
1881	3.6	−0.3	.09	31.0	−4	16	+ 1.2
1882	3.2	−0.7	.49	34.0	+0.5	....	− 0.4
1883	4.2	+0.3	.09	24.2	−9	81	− 2.7
1884	3.8	−0.1	.01	33.3	−0.2	....	....
1885	3.2	−0.7	.49	36.8	+3	9	− 2.1
1886	2.9	−1.0	1.00	33.5	−0.03	....	....
1887	2.2	−1.7	2.89	30.5	−3	9	+ 5.1
1888	4.4	+0.5	.25	38.9	+5	25	+ 2.5
1889	4.2	+0.3	.09	32.3	−1	1	− 0.3
1890	2.0	−1.9	3.61	24.6	−9	81	+17.1
1891	3.8	−0.1	.01	35.6	+2	4	− 0.1
1892	3.8	−0.1	.01	33.3	−0.2	....	....
1893	2.5	−1.4	1.96	29.1	−4	16	+ 5.6
1894	1.6	−2.6	6.76	32.6	−4	16	+10.4
1895	2.0	−2.2	4.84	33.7	−3	9	+ 6.6
1896	8.1	+3.9	15.21	41.7	+5	25	+19.5
1897	4.6	+0.4	.16	34.3	−3	9	− 1.2
1898	4.0	−0.2	.04	37.4	+0.4	....	− 0.1
1899	4.2	+0.01	.0001	38.1	+1	1	....
1900	4.6	+0.4	.16	42.6	+6	36	+ 2.4
1901	2.7	−1.5	2.25	30.0	−7	49	+10.5
1902	4.7	+0.5	.25	38.8	+2	4	+ 1.0
1903	3.7	−0.5	.25	31.5	−6	36	+ 3.0
1904	4.1	−0.1	.01	32.8	−4	16	+ 0.4
1905	3.9	−0.3	.09	37.9	+1	1	− 0.3
1906	5.1	+0.9	.81	42.2	+5	25	+ 4.5
1907	5.4	+1.2	1.44	34.8	−2	4	− 2.4
1908	4.1	−0.1	.01	36.1	−1	1	+ 0.1
1909	3.8	−0.4	.16	38.7	+2	4	− 0.8
1910	3.2	−1.0	1.00	36.6	−0.4	....	+ 0.4
1911	2.4	−1.8	3.24	38.6	+2	4	− 3.6
1912	5.7	+1.5	2.25	42.8	+6	36	+ 9.0
1913	5.2	+1.0	1.00	37.8	+1	1	+ 1.0
Sum	....	....	111.83	....	....	1,045	+203.2

Correlation with other months.—It follows that by making similar correlations for other periods in the growth of the corn plant the time when the rainfall has the greatest effect can be accurately determined. The Weather Bureau records show monthly amounts of rainfall, hence in these early data the rainfall for complete months only can be used.

Correlation coefficient tables for Ohio for 60 years for other months worked out exactly as shown in Table 1 give the following:

Period of rainfall.	Correlation coefficient r
July	+0.59
June	+0.12
August	+0.37
June and July	+0.48
July and August	+0.67
June, July, and August	+0.57

This makes it plain that the rainfall for the month of July has a far greater effect upon the yield of corn in Ohio than either June or August, somewhat greater than the rainfall for June and July combined, and slightly greater than for June, July, and August combined, but that the rainfall for July and August combined has a greater effect than for July alone.

Results of variations in July rainfall.—The average rainfall for the State of Ohio in July for the past 60 years is 4.06 inches. The average yield of corn for Ohio for the 60 years is 34.5 bushels per acre. If the different years are grouped by July rainfall amounts the yield figures show some very interesting results.

For example, if all of the rainfalls of one-fourth inch differences be grouped and the yield figures averaged, the results will show an average increase in the yield of corn of 0.8 bushel per acre with each increase in the rainfall of one-fourth inch. That is, if all of the years when the rainfall for July was less than 1.75 inches, be grouped together then all of the years when the rainfall was between 1.75 inches and 2 inches, between 2 inches and 2.25 inches, and so on up to 8 inches, the increase in the average yield values will amount to 0.8 bushel per acre with each rainfall increase. Between 2 and 4 inches the average increase in yield with each increase in the rainfall of one-fourth inch amounts to 1.4 bushels per acre.

If the rainfall amounts are grouped for each half-inch difference, the average increase in the yield with each increase in the July rainfall of one-half inch is 1.2 bushels per acre. The average yield of corn for all of the years when the rainfall for July was between 2.50 inches and 3 inches is 29.8 bushels per acre, while the average yield for all of the years when the rainfall was between 3 inches and 3.50 inches was 34.1 bushels per acre. This is an average increase of 4.3 bushels per acre in the corn yield for the whole State of Ohio when there is an increase in the rainfall of only one-half inch, at what seems to be the critical rainfall stage in July.

The average increase in the corn yield with each increase of 1 inch in the rainfall in July in Ohio is 2.3 bushels per acre. Between 2 inches and 6 inches the yield increases at an average rate of 2.5 bushels per acre for each increase of 1 inch in the July rainfall. The greatest rate of increase is when the rainfall passes the 3-inch mark.

In all of the years when the rainfall in July in Ohio has averaged less than 3 inches the average corn yield has been 30.3 bushels per acre. In the years when the rainfall for July has been 5 inches or above, the corn yield has averaged 38.1 bushels per acre.

The records of crop production show that the area devoted to corn in Ohio for the 10 years from 1903 to 1912, inclusive, has averaged slightly over 3,500,000 acres

each year. The average farm price for corn on December 1 during the same period has been 50 cents per bushel in Ohio.

Combining these figures with the yield values in the preceding paragraphs we see at once that each increase of one-fourth inch in rain in July over the State of Ohio causes an average increase in the total corn yield of 2,800,000 bushels, with a value of $1,400,000. Also that between 2 and 4 inches each increase in rain amounting to one-fourth inch increases the value of the corn crop in Ohio $2,950,000.

The figures show further that each increase in the rainfall in July of one-half inch will cause an average increase in the corn yield in Ohio of 4,200,000 bushels, worth on December 1 on the farm $2,100,000. And not only that, but when the rainfall for July passes the 3-inch mark the increase in the corn crop with an increase in the rainfall of only one-half inch will, on the average, amount to 15,050,000 bushels, worth $7,525,000 when corn is worth 50 cents a bushel on the farm.

For each variation of 1 inch in the rainfall for July the corn yield in Ohio varies 2.3 bushels per acre or 8,050,000 bushels.

When the rainfall for July in Ohio has been less than 3 inches the yield of corn has averaged 30.3 bushels per acre, and when the fall has been 5 inches or more the yield has averaged 38.1 bushels per acre. This difference of 7.8 bushels per acre means 27,300,000 bushels of corn for the State, worth $3.90 an acre, or $13,650,000, depending on whether the State has had an average of 3 inches or less of rain in July or whether the fall has been 5 inches or more.

It must be remembered that these figures are only averages and it does not follow that the yield will vary as indicated every time that the rainfall for July varies one-fourth or one-half inch, etc. Sometimes the variation will be greater and sometimes less, but inasmuch as the study covers the unusually long period of 60 years the figures must be valuable.

The practical application of this study comes in recognizing the fact that one-fourth and even one-half an inch of rain can be conserved from rapid evaporation by proper cultivation.

CORRELATION FOR SHORTER PERIODS THAN MONTHS.

The rainfall in the preceding correlations and discussions was for complete months so the next step seemed to be the tabulation of the rainfall into shorter periods to try and determine the exact time during which the rainfall has its greatest effect upon the corn yield.

At first this was done by correlating the rainfall at one station for each 10 days with the yield of corn in the county in which the station is located. Wooster, Ohio, and Wayne County were considered with the following result:

TABLE 2.—*Correlation of rainfall at Wooster, Ohio, for each 10 days and yield of corn in Wayne County, 1891 to 1910.*

Periods.	Correlation coefficient r.
June 21 to 30	+0.31
July 1 to 10	+ .12
July 11 to 20	**+ .71**
July 21 to 31	+ .16
August 1 to 10	+ .56
August 11 to 20	+ .46
August 21 to 31	+ .14
September 1 to 10	+ .36

This gives such a high value of r for the 10 days from July 11 to 20 as compared with the periods on either side, that the reliability of comparing the rainfall at one point alone in a county with the yields for that county was seriously doubted.

We therefore calculated the average yield of corn for the three counties of Franklin, Madison, and Pickaway, in central Ohio, and the average rainfall for 18 coöperative stations in and around these counties. The period covered was from 1891 to 1910, inclusive, and we believe that a correlation with the averages obtained in this manner has a high degree of accuracy.

The same method of correlation was used as has been described in Table 1, and the correlation was made for each 10, 20, 30, 40, and 50 days, as shown by the following tables:

TABLE 3.—*Relation between rainfall and yield of corn in central Ohio for 10-day periods, 1891 to 1910.*

Periods.	Correlation coefficient r.
June 1 to 10	−0.09
June 11 to 20	+ .12
June 21 to 30	− .04
July 1 to 10	+ .16
July 11 to 20	+ .36
July 21 to 31	+ .36
August 1 to 10	**+ .52**
August 11 to 20	+ .29
August 21 to 31	− .06

This table seems to show plainly that the 10-day period from August 1 to 10 has the greatest influence upon the yield of corn in central Ohio. The probable error for that correlation coefficient is ± 0.10, which is fairly low.

TABLE 4.—*Relation between rainfall and yield of corn in central Ohio for 20-day periods, 1891 to 1910.*

Periods.	Correlation coefficient r.
June 1 to 20	+0.03
June 11 to 30	− .10
June 21 to July 10	+ .07
July 1 to 20	+ .36
July 11 to 31	+ .41
July 21 to August 10	**+ .50**
August 1 to 20	+ .45
August 11 to 31	+ .20

The highest value of r in this table is $+0.50$ from July 21 to August 10, and this is just five times the probable error.

TABLE 5.—*Relation between rainfall and yield of corn in central Ohio for 30-day periods, 1891 to 1910.*

Periods.	Correlation coefficient r.
June 1 to 30	−0.02
June 11 to July 10	+ .11
June 21 to July 20	+ .26
July 1 to 31	+ .43
July 11 to August 10	**+ .49**
July 21 to August 20	+ .48
August 1 to 31	+ .37

Here the greatest coefficient is for the period July 11 to August 10, when r is $+0.49$, and the probable error is ± 0.10. These last three tables seem to show that the rainfall before July 10 does not have a very great effect upon the yield of corn. Also that the rainfall after August 11 need not be taken very seriously into account. The tables show further that the correlation coefficient for the 10 days of August 1 to 10 is higher than for any 20 or any 30 day period, although the difference is slight.

TABLE 6.—*Relation between rainfall and yield of corn in central Ohio for 40-day periods, 1891 to 1910.*

Periods.	Correlation coefficient r.
June 1 to July 10	+0.07
June 11 to July 20	+ .24
June 21 to July 31	+ .36
July 1 to Aug. 10	+ .53
July 11 to August 20	**+ .60**
July 21 to August 31	+ .52

There seems little question in this table of the dominating influence of the rainfall during the period from July 11 to August 20. This correlation coefficient of +0.60 is nearly seven times the probable error.

TABLE 7.—*Relation between rainfall and the yield of corn in central Ohio for 50-day periods, 1891 to 1910.*

Periods.	Correlation coefficient r.
June 1 to July 20	+0.17
June 11 to July 31	+ .36
June 21 to August 10	+ .49
July 1 to August 20	**+ .59**
July 11 to August 31	+ .55

The correlation coefficient from July 1 to August 20 in this table is +0.59 and is slightly more than six times the probable error.

We believe that the district covered by the yield and rainfall figures in Tables 3 to 7 makes them very reliable and that the values may be taken as a standard for this section of the country. Similar tables should be worked out for other districts, however, as the correlations might vary under different distribution of rainfall or different temperature and sunshine.

It may be well again to call attention to the differences shown in Table 3 as compared with Table 2, in order to emphasize the importance of having sufficient data so that incorrect conclusions may be avoided.

WEATHER EFFECTS DURING DIFFERENT PERIODS OF DEVELOPMENT.

After showing the relation between the corn yield and a single element, the rainfall during certain definite periods, the question naturally arises: What is the effect of all the elements, i. e., the weather during different periods of development of the corn plant? This question can be answered by a study of certain data that have been compiled at Wauseon, Fulton County, Ohio.

Mr. Thomas Mikesell, of this place, has kept a most remarkable record of phenological data for the past 30 years. He has a wonderfully complete record of the advance o all field and garden crops, of fruit and forest trees, shrubs, grasses, weeds, etc., of all varieties, as well as of the migration of birds and the activities of insects, animals, etc. At the same time he has kept a daily record of temperature and rainfall with well-exposed standard instruments.

In Table 8 there have been entered certain important data relating to corn growth and development from 1883 to 1912 as taken from the records of Mr. Mikesell. As will be seen, they cover the dates planted, dates that the plants appear above ground, the date in blossom, and the date ripe, together with a statement of the quantity and quality of the crop.

From 1883 to 1901 the dates are for operations on his own farm, and during the balance of the period for certain nearby fields, the same field being used for the entire season. The average dates and periods of development are given at the bottom of the table.

TABLE 8.—*Phenological dates and data for growth of corn at Wauseon, Ohio, 1883 to 1912, by Thomas Mikesell.*

[Lat., 41° 35′ N; long., 84° 07′ E.; alt., 780 feet A. M. S. L.]

Year.	Date planted.	Date above ground.	Days from planting to above ground.	Date in blossom.	Days from above ground to blossom.	Date ripe.	Days from blossom to ripe.	Per cent of good crop.	Quality of crop.
1883	May 12	May 25	13	July 29	65	Oct. 10	73	60	Poor.
1884	16	24	8	24	61	Sept. 15	53	90	Good.
1885	18	25	7	23	59	26	65	65	Fair.
1886	11	19	8	17	59	15	60	85	Good.
1887	20	25	5	24	60	15	53	60	Fair.
1888	15	25	10	25	61	20	57	75	Fair.
1889	15	23	8	Aug. 3	72	30	58	85	Good.
1890	27	June 1	5	July 26	55	20	56	50	Fair.
1891	12	May 22	10	27	66	18	53	60	Good.
1892	June 18	June 23	5	Aug. 6	44	25	50	60	Fair.
1893	May 18	May 28	10	July 25	58	12	49	60	Good.
1894	1	10	9	17	68	Aug. 30	44	60	Fair.
1895	1	7	6	22	76	Sept. 10	50	80	Good.
1896	9	14	5	10	57	Aug. 30	51	100	Good.
1897	22	June 5	14	20	45	Sept. 12	54	80	Good.
1898	18	May 25	7	20	56	Aug. 31	42	......	......
1899	18	27	9	17	51	30	44	90	Good.
1900	......	......	......	......	......	Sept. 6	......	......	......
1901	May 12	May 27	15	July 18	52	5	49	......	......
1902[1]	......	......	......	......	......	3	......	......	......
1903	......	......	......	......	......	......	......	......	......
1904	May 7	May 17	10	July 25	69	Sept. 10	47	80	Good.
1905	9	15	6	18	64	Aug. 30	43	75	Good.
1906	10	16	6	17	62	Sept. 10	55	80	Good.
1907	Apr. 26	6	10	30	85	3	35	75	Good.
1908	May 21	28	7	30	63	15	47	80	Good.
1909	14	21	7	Aug. 6	77	25	50	80	Good.
1910	11	21	10	1	72	30	60	90	Fair.
1911	10	17	7	July 20	64	8	50	80	Fair.
1912	10	20	10	22	63	2	42	95	Good.
Average	May 14	May 23	9	July 25	62	Sept. 13	50	76	

[1] Data for the years 1883 to 1901, inclusive, apply to Mr. Mikesell's own estate; data for 1902 to 1912 apply to certain nearby fields, the same field being used for the entire season.

Thermal constants.—The "thermal constant" of a crop is the average sum of the daily mean temperatures necessary to bring it to maturity. Thermal constants have been worked out at many of the European experiment stations and it has been determined that the amount of heat necessary to bring a certain crop to maturity in the same locality does not vary very much in different years. If the temperature is comparatively low, the ripening is correspondingly delayed. But there have been marked differences among investigators as to the temperature data to be considered and the point from which the thermal constant should be calculated.

Botanists state that the protoplasmic contents of vegetable cells are inactive when the temperature is below 6° C. (42.8° F.); that the protoplasm begins to awaken into life when this temperature is reached, and will grow and multiply as the temperature rises above this point.

It seems to the writer that 43° F. should be adopted as the point of departure in calculating "thermal constants." Also that the daily temperatures used should be the mean of the daily maximum and minimum temperatures obtained in the shade. These are the daily means used by the United States Weather Bureau and are the most available. [Necessary corrections to be applied in obtaining the true daily mean temperature are given in Weather Bureau Bulletin S.]

For the spring-seeded crops we believe that the thermal constant or effective temperature record should begin with the date of seeding and end with the date of ripening. For fall-seeded crops the record should also begin with the date of seeding and all winter days be used when the mean temperature for the day is above 43°. It might be said that when grain is covered with snow an air temperature above 43° has no effect upon the plant. But on

the other hand if the ground is not frozen the plant may be growing slightly while covered with snow even with the temperature over the snow cover below 43°. In the case of fruits it is probable that the "thermal constant" should be calculated from the beginning of the formation of the fruit buds during the preceding summer.

The method used for obtaining the "thermal constant" as noted above is quite simple. Thus if the mean temperature for any month is 65° F. the daily effective temperature is 65° minus 43°, or 22°. The thermal constant for the month will be found by multiplying the daily effective temperature, 22, by the number of days in the month.

If the daily mean temperature during any part of a month has been 43° or below, these days should be omitted and only those days used when the average daily temperature is 44° and above. This can be done by either of two methods: (1) Find the difference between the mean temperature and 43° for each day separately and add the sums together, or (2) get the mean temperature for the days when the mean is 44° and above, subtract 43°, and multiply by the number of days.

THERMAL AND RAINFALL CONSTANTS AT WAUSEON, OHIO.

Thermal and rainfall constants have been worked out for the different stages of growth of corn at Wauseon, Ohio, for 1883 to 1912, and appear in Table 9. In addition, the amount of available heat and the rainfall for 10 days before the date of planting was determined and appears in the table.

This table should be studied in connection with the data in Table 8 for the dates of planting, blossoming, etc., and the number of days between these dates during different years.

TABLE 9.—*Thermal and rainfall constants during the growth of corn at Wauseon, Fulton County, Ohio, 1883 to 1912.*

Year.	Thermal.						Rainfall.						
	10 days before planting.	Planting to above ground.	Above ground to blossoming.	Blossoming to ripening.	10 days before blossoming.	10 days after blossoming.	10 days before planting.	Planting to above ground.	Above ground to blossoming.	Blossoming to ripening.	5 days before to 5 days after blossoming.	10 days before blossoming.	10 days after blossoming.
	° F.	° F.	° F.	° F.	° F.	° F.	In.	In.	In.	In.	In.	In.	In.
1883	139	141	1,583	1,264	270	290	0.6	2.7	13.7	6.1	0.7	3.7	0.0
1884	114	161	1,496	1,412	240	290	1.0	0.8	6.0	5.9	1.1	0.0	4.5
1885	114	147	1,520	1,432	330	340	0.1	1.6	6.6	8.4	1.8	0.2	2.6
1886	134	128	1,477	1,565	290	260	0.9	0.9	2.8	5.5	T.	T.	0.2
1887	205	131	1,693	1,371	350	330	0.1	1.4	8.4	1.9	1.0	1.0	0.0
1888	128	110	1,600	1,410	270	320	1.4	0.4	5.6	2.7	0.1	0.1	0.4
1889	250	143	1,649	1,239	250	240	1.3	0.4	15.3	2.3	1.0	1.6	0.9
1890	167	131	1,365	1,330	270	360	1.1	T.	4.4	6.3	T.	T.	T.
1891	103	148	1,568	1,366	260	250	0.4	0.6	6.6	4.0	0.4	0.4	0.4
1892	318	165	1,253	1,238	310	310	1.0	1.2	5.3	6.2	0.3	1.2	T.
1893	140	163	1,634	1,411	300	300	1.0	0.3	8.4	1.4	0.4	1.0	0.4
1894	139	161	1,638	1,309	290	330	0.9	1.3	5.3	1.1	0.2	T.	0.2
1895	157	175	1,919	1,428	250	270	T.	1.2	2.3	3.8	0.7	0.2	0.5
1896	235	154	1,443	1,490	280	290	0.2	0.6	8.2	13.8	4.0	1.4	6.4
1897	153	186	1,232	1,486	290	320	1.0	1.2	5.4	3.5	1.0	1.7	1.3
1898	150	177	1,566	1,259	...	...	1.7	1.4	6.1	4.7	...	...	...
1899	169	154	1,478	1,344	290	320	1.4	1.2	4.7	2.3	2.8	2.2	1.2
1900	...	...	...	...	...	...	...	...	...	...	...	...	...
1901	151	201	1,468	1,546	...	...	0.8	1.8	8.3	2.2	...	...	...
1902	...	...	...	...	...	...	...	...	...	...	...	...	...
1903	...	...	...	...	...	...	...	...	...	...	...	...	...
1904	146	109	1,637	1,140	290	270	0.1	0.6	6.5	3.6	0.8	1.6	0.6
1905	142	97	1,526	1,210	290	270	0.8	3.3	10.2	2.9	0.1	0.1	0.2
1906	91	127	1,574	1,607	300	280	0.6	0.4	6.8	6.1	0.3	2.3	0.2
1907	−25	36	1,762	897	290	160	0.4	0.8	10.7	3.3	1.4	1.3	2.0
1908	213	199	1,735	1,229	300	300	2.6	0.4	9.6	3.4	0.0	2.1	0.2
1909	135	107	1,984	1,223	310	300	2.5	0.4	10.7	6.0	0.5	1.1	2.6
1910	78	114	1,811	1,453	290	260	1.0	0.7	6.6	6.9	0.1	3.4	T.
1911	125	166	1,913	1,322	290	230	0.1	T.	10.2	5.0	1.1	1.0	0.8
1912	168	123	1,645	1,107	300	270	0.8	2.2	5.3	5.1	0.6	0.8	0.8
Means	150	143	1,599	1,337	296	286	0.9	1.0	7.4	4.6	0.8	1.1	1.1

In Table 8, for example, the average date for planting corn is May 14, and the average number of days for the plants to appear above the ground is nine. Table 9 shows that the average number of degrees during this period has been 143°, and the average rainfall 1 inch.

The average time from the date the plants appear above the ground until they are in blossom is 62 days, and the thermal constant averages 1,599°. The rainfall averages 7.4 inches. The average date that the corn is in blossom at Wauseon is July 25, although this date has varied between July 10 and August 6.

The average date that the corn has ripened is September 13, or 50 days after the date of blossoming. The average thermal constant during this time is 1,337°, and the average rainfall 4.6 inches.

Table 9 also gives the thermal and rainfall constants for 10 days before blossoming and for 10 days after blossoming, as well as the rainfall during the 10-day period from five days before to five days after blossoming.

Thermal constants and corn yield, Wauseon, Ohio.—In Table 10 the correlation coefficients have been given between the thermal constants during different periods of corn development and the percentage of a good crop, as reported by Mr. Mikesell. It is unfortunate that we do not have the yield of corn in bushels per acre, yet believe that the percentage figures have been carefully considered by the observer.

TABLE 10.—*Results of correlation between thermal constants and corn yield, Wauseon, Ohio, 1883 to 1912.*

Correlation factors.	Correlation coefficient r
(1) Thermal constants for 10 days before planting and yield	−0.03
(2) Thermal constants from date of planting to date above ground and yield	−.03
(3) Thermal constants from date above ground to date of blossoming and yield	+.18
(4) Thermal constants from date of blossoming to date ripe and yield	+.08
(5) Daily mean temperature for 10 days before blossoming and yield	−.003
(6) Daily mean temperature for 10 days after blossoming and yield	−.28

There is a slight positive relation between the temperature between the date that the corn appears above the ground and the date of blossoming and the yield of corn, as well as a negative relation between the temperature for 10 days after blossoming and the yield, but the correlation coefficients are all too low to be given any consideration.

Thus Table 10 seems to show that there is little or no relation between the daily mean temperature and the yield of corn.

Rainfall constants and corn yield, Wauseon, Ohio.—In Table 11 the correlation coefficients between the yield of corn and the rainfall during the different periods of growth are shown.

TABLE 11.—*Results of correlation between rainfall constants and corn yield, Wauseon, Ohio, 1883 to 1912.*

Correlation factors.	Correlation coefficient r
(1) Rainfall for 10 days before planting and yield of corn	+0.01
(2) Rainfall from date of planting to date above ground and yield	−.06
(3) Rainfall from date above ground to date of blossoming and yield	−.03
(4) Rainfall from date of blossoming to date ripe and yield	+.29
(5) *Rainfall from 5 days before blossoming to 5 days after blossoming and yield*	*+.45*
(6) Rainfall for 10 days before blossoming and yield	+.20
(7) **Rainfall for 10 days after blossoming and yield**	**+.74**
(8) Rainfall for 20 days after blossoming and yield	+.57
(9) Rainfall for 30 days after blossoming and yield	+.46

The results from this table are very important. It seems to make plain that there is no relation between the rainfall in the first part of the period of growth of the corn crop and the yield. The average date of blossoming as determined in Table 8 is July 25, 62 days after the plants appear above the ground and 71 days after planting.

The correlation coefficient for the first three items in Table 11 are much too near zero to receive consideration. The correlation coefficient in item 4 indicating the relation between the rainfall between the dates of blossoming and ripening is +0.29, but as this is only two and one-half times the probable error even this is not very close.

The value of *r* for the rainfall for 10 days before the date of blossoming as given in item 6 is also too low to be given serious consideration. In item 5, however, covering the time from five days before blossoming to five days after blossoming, the value of *r* is four times the probable error and a relation is apparently established.

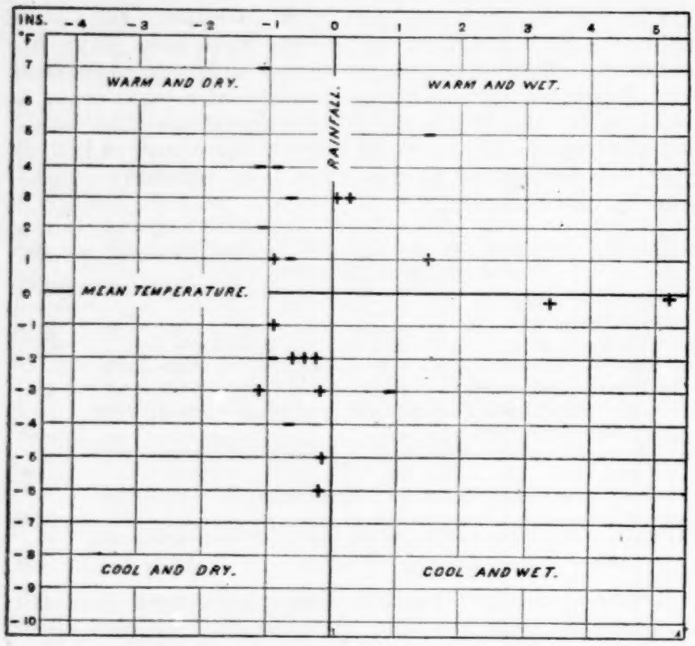


FIG. 1.—Dot chart showing combined effect of temperature and rainfall during the 10 days following the date of blossom upon the yield of corn at Wauseon, Ohio, 1883-1912. +, yield above normal; −, yield below normal.

It is in item 7 of Table 11, however, that we have the highest correlation coefficient. This shows that the rainfall for the 10 days after blossoming has the greatest effect upon the yield of corn of any period in the history of the plant. This value of *r* is +0.74, which is 15 times the probable error. This coefficient is considerably higher even than that for the 20 days or the 30 days following the date of blossoming.

In Tables 3, 4, and 5, there were given the correlation coefficients for the rainfall for the State of Ohio as a whole compared with the yield of corn, for arbitrary 10, 20, and 30 day periods. All near the average date of blossoming gave high values of *r*. These facts combined with the high value of *r* in item 7 of Table 11 go to show that the rainfall immediately after blossoming has a very dominating effect upon the yield of corn.

Combined effect of rainfall and temperature.—Item 7 in Table 11 indicates a direct relation between the rainfall for 10 days after blossoming and the yield of corn, and item 6 in Table 10 seems to show an opposite effect of the temperature upon the yield, during the same period.

In figure 1, therefore, the combined effect of these two factors is shown by a dot chart. In this chart the mean or normal temperature is indicated by a central horizontal line. Lines above this normal line indicate temperatures above the normal and lines below it temperatures below the normal. The normal rainfall is indicated by a central perpendicular line and the rainfall values above and below the normal are indicated by lines to the right and left of the central line, respectively.

The dot chart is made by placing a yield dot at the intersection of the lines indicating the departure of the temperature and the rainfall from the normal. If the yield is above the normal a cross or plus mark is entered, and if the yield is below the normal a minus sign is set down. If there is a decided effect of either or of both factors there will be a well defined grouping of the plus and the minus signs.

Figure 1 seems to make plain the fact that warm and dry weather for 10 days after blossoming is very damaging to the corn yield and that wet weather is beneficial. It shows also that if dry weather is also cool the result is generally favorable.

Correlation between weather factors.—Sometimes a weather factor seems to show a favorable or unfavorable effect upon the yield when in fact the real effect is due to another weather condition entirely, which itself determines the first factor.

It is sometimes true that wet weather is also cool weather or that wet and warm weather occur together over a district. To ascertain whether this is the case in the development of corn some correlations have been determined for Wauseon as given in Table 12.

TABLE 12.—*Results of correlation between thermal constants and rainfall, and also other factors, Wauseon, Ohio, 1883 to 1912.*

Correlation factors.	Correlation coefficient *r*.
(1) Thermal constants from date above ground to date of blossoming of corn and total rainfall for same period...	+0.42
(2) Thermal constants and total rainfall from date of blossoming of corn to date ripe...	+ .28
(3) Thermal constants and total rainfall from date of planting of corn to date that it is ripe...	− .11
(4) Thermal constants from date of planting of corn to date it is ripe and the total number of days in same period....	+ .37
(5) Relation of total number of days from date of planting of corn to date it is ripe and the yield of corn...	− .001

The above values of *r* show that warm weather accompanies wet weather more than half of the time during the first part of the growth of corn, but that for the whole period any apparent relation is accidental.

RATE OF GROWTH OF CORN.

A number of years ago the Pennsylvania State Agricultural Experiment Station carried out some experiments showing the rate of growth of corn, and tables showing the results were published in their annual reports for 1887, 1888, and 1889.

The period covered in 1889 was from July 5 to 27, when the average rate of growth of corn was 139 thousandths of a foot in the daytime and 198 thousandths of a foot in the nighttime. In this discussion the "daytime" was for 9.5 hours, from 7:30 a. m. to 5 p. m., and the "nighttime" was from 5 p. m. to 7:30 a. m., or 14.5 hours. The hourly rate of growth during this period was 13.6 thousandths of a foot at night and 14.7 thousandths of a foot in the daytime.

Temperature data are given in the tables in connection with the rate of growth and from those tables figures 2

and 3 have been prepared. Figure 2 gives the general relation between the maximum temperature and the rate of growth in the daytime and indicates a close connection.

Figure 3, however, indicates that the rate of growth of the corn plant at night follows along with and is very largely controlled by the minimum temperature.

Effect of minimum temperatures at Wauseon, Ohio.—With the curves in figure 3 in mind correlations were calculated between the minimum temperatures at Wauseon, Ohio, and the yield of corn. The results are given in Table 13.

TABLE 13.—*Results of correlation between mean minimum temperatures and corn yield, Wauseon, Ohio, 1883 to 1912.*

Correlation factor.	Correlation coefficient r.
(1) Mean minimum temperatures for 10 days before blossoming and yield	−0.01
(2) Mean minimum temperatures for 10 days after blossoming and yield	− .01
(3) Mean minimum temepratures from date corn appears above ground to date of blossoming and yield	− .07
(4) Mean minimum temperatures from date of blossoming to date corn is ripe and yield	+ .33

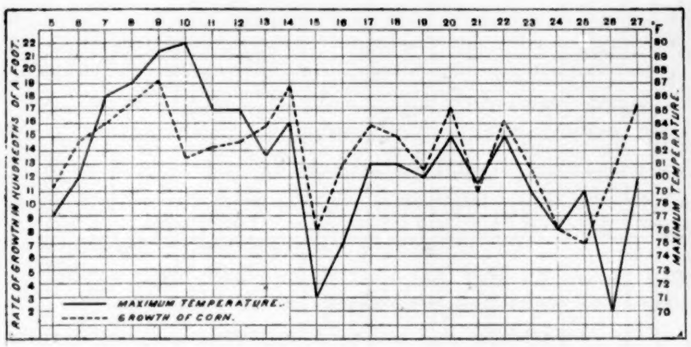


FIG. 2.—Relation between maximum temperature and daily growth of corn in Pennsylvania, July 5-27, 1889.

This shows no relation whatever between the minimum temperature and the yield of corn except during the period from the date of blossoming to date of ripening. This is rather low and we believe is entirely accidental, because the Pennsylvania experiments found that the vertical growth of corn practically ceases when the plants tassel out.

Effective rainfalls.—It is well known that small rainfalls during a drought may actually do more harm to a crop than good, because by merely wetting the surface of the ground an effective dust mulch may be destroyed and thus more water be lost to the crop by evaporation than has been gained by the shower.

Or numerous light showers during the early growth of the corn, by merely wetting the surface may cause it to root near the surface where the soil will quickly dry out during later dry spells. In our own investigations of accumulative effects of weather it was found that when July was quite dry the final yield was greater if the previous June was moderately dry also.

Of course the rate of growth and development of corn plants have been determined with certain definite amounts of water, in the laboratory. But to try and answer the often repeated question as to just what rainfall amounts are actually beneficial to the growing corn, or are most beneficial, we have adopted the following plan:

The rainfall for a definite district and period is multiplied by the total number of days with a certain amount of rain or more and divided by the whole number of days in the period. The equation is simple:

$$\frac{ab}{c},$$

where a is the total rainfall for the period, b the number of days with 0.10 inch, 0.20 inch, 0.30 inch, etc., rainfall or more, and c the total number of days in the period.

In Table 14 the effective rainfall was determined by taking the rainfall at Columbus, Ohio, for the 51-day period from June 21 to August 10, for 20 years, working out new factors in accordance with the formula as above, and correlating these new factors with the yield of corn in Franklin County, Ohio.

This method shows whether a certain amount of rain is as effective coming in many small showers, as it is in a few heavy showers, and it is accomplished by eliminating consideration of days with rainfalls below the definite amounts.

The general rule has been stated that for equal quantities of rain its value to agriculture increases as the number of rainy days diminishes, and on the other hand

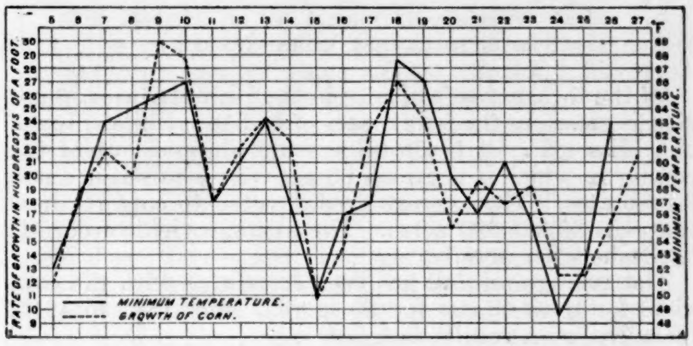


FIG. 3.—Relation between minimum temperature and nocturnal growth of corn in Pennsylvania, July 5-27, 1889.

diminishes as the number of rainy days increases. This can be true, however, only up to a certain point.

TABLE 14.—*Correlation table for determining the most effective rainfall in the yield of corn in Columbus and Franklin Counties, Ohio.*

Rainfall factors.	Correlation coefficient r.
Rainfall for July and yield of corn	+0.48
Rainfall, June 21 to August 10, and yield of corn	+ .60
Factor determined for the amounts given below as per formula and the yield of corn:	
Days with 0.01 inch or more	+ .61
Days with 0.10 inch or more	+ .61
Days with 0.20 inch or more	+ .61
Days with 0.25 inch or more	+ .64
Days with 0.30 inch or more	+ .59
Days with 0.40 inch or more	+ .61
Days with 0.50 inch or more	+ .70
Days with 0.60 inch or more	+ .55
Days with 0.70 inch or more	+ .56
Days with 0.75 inch or more	+ .57
Days with 0.80 inch or more	+ .38
Days with 0.90 inch or more	+ .59
Days with 1.00 inch or more	+ .41

This table shows quite plainly that rainfalls of 0.50 inch or more are the most effective in determining the yield.

For fear that the results might be affected by taking the rainfall at only one station, similar correlations have been calculated for the yields in Franklin, Madison, and Pickaway Counties, in central Ohio, and for the rainfall

at all of the stations in and around those counties, 18 in all, for the period from July 21 to August 10. The results follow in Table 15.

TABLE 15.—*Results from correlations for most effective rainfalls, Central Ohio, 1891 to 1910.*

Correlation factors.	Correlation coefficient r.
Rainfall, July 21 to August 10, and corn yield (see Table 4)...	+0.50
Factor determined for the amounts below as per formula and the yield of corn:	
Days with 0.01 inch or more	+ .44
Days with 0.10 inch or more	+ .51
Days with 0.20 inch or more	+ .43
Days with 0.25 inch or more	+ .49
Days with 0.30 inch or more	+ .50
Days with 0.40 inch or more	+ .47
Days with 0.50 inch or more	+ .64

The differences in the correlation coefficients for the lower rainfall amounts are not great and could be purely accidental. But the higher value of r for 0.50 inch or more, corresponds to that determined in Table 14 and seems to show that one-half of an inch of rain is more beneficial than lesser amounts.

FOUR GREATEST CORN STATES.

Of the total acreage of corn in the United States 30 per cent is grown in the four States of Indiana, Illinois, Iowa, and Missouri. Of the total amount shipped out of the county in which it is grown 60 per cent is raised in these four States. The average area devoted to corn in these States is 30,325,300 acres. The average yield of corn is 32 bushels per acre.

The average rainfall has been correlated with the corn yield for these States for the period from 1888 to 1911, inclusive, with results as follows:

TABLE 16.—*Results of correlation of rainfall with the corn yield for Indiana, Illinois, Iowa, and Missouri, 1888 to 1911.*

Correlation factors.	Correlation coefficient r.
Rainfall for June and corn yield	+0.34
Rainfall for July and corn yield	+ .73
Rainfall for August and corn yield	+ .48
Rainfall for June and July and corn yield	+ .68
Rainfall for July and August and corn yield	+ .69
Rainfall for June, July, and August and corn yield	+ .69

This shows that the rainfall for July has a greater effect upon the yield of corn than that for either June or July, or for a combination of these months with July.

An analysis of the rainfall and yield data in these States, as was made for Ohio, shows that the average increase in the corn yield with each increase of one-half inch in the rainfall in July amounts to 2 bushels per acre. This means a total increase in the corn yield of 61,000,000 bushels, worth thirty and one-half million dollars when corn is worth 50 cents per bushel.

In these four States when the rainfall for July has been between 2 and 2.5 inches the yield of corn has averaged 23 bushels per acre, and when the rainfall has been between 2.5 inches and 3 inches the yield has averaged 33 bushels per acre. This is an increase of 10 bushels per acre with an increase of only one-half inch of rain at the critical rainfall stage. But this increase amounts to the enormous quantity of 300,000,000 bushels, worth something like \$150,000,000. This also means an increase in the value of the corn crop of \$5 per acre when corn is worth 50 cents per bushel.

A correlation of the mean temperature in July over these four States with the yield of corn shows a negative relation amounting to −0.61. Investigation seems to show that this is due to the fact that cool weather usually accompanies rain in July.

Figure 4 explains this and shows the combined effect of rainfall and temperature differences upon the yield of corn in these four States in July. This indicates that warm and dry weather in July is always unfavorable, and that wet weather is usually favorable. Also that if the weather is dry a good crop is apt to be gathered, if it is cool also.

This chart explains that it is not warm weather alone that is unfavorable but high temperature coupled with dry weather.

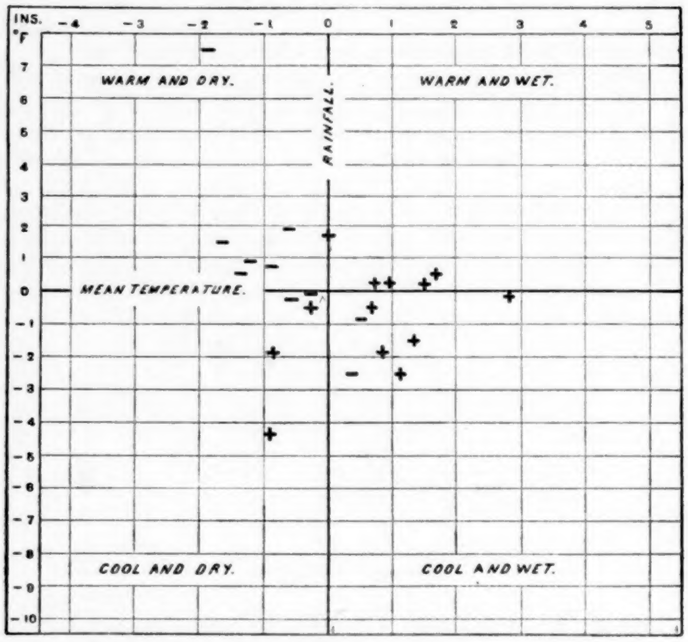


FIG. 4.—Dot chart showing combined effect of rainfall and mean temperature in July upon yield of corn. Averages for Indiana, Illinois, Iowa, and Missouri, 1889-1911. +, yield above normal; −, yield below normal.

Rainfall and corn yield in eight States.—In Table 17 is given the regular correlation table showing the relation between the average rainfall for the month of July and the yield of corn in bushels per acre over Ohio, Indiana, Illinois, Iowa, Nebraska, Kansas, Missouri, and Kentucky, for the past 25 years.

The correlation coefficient in this case is +0.78, while the probable error is only ±0.05. This is a very high correlation and indicates the high effect of the July rainfall alone when considering large districts.

An inspection of the table brings out the fact that an excess in the rainfall has always been followed by an excess in the corn yield. Also that a deficiency in the rainfall in July has been followed by a deficient yield every year except four, and in each one of these years the rainfall deficiency was slight.

The normal rainfall over these eight States in July is 3.9 inches, and the normal yield of corn 30 bushels per acre. The average area devoted to corn is close to 50,000,000 acres.

The yield of corn during those years when the rainfall averages one-half inch less than the normal or less has been 23 bushels per acre. On the other hand, when the rain has been one-half inch or more above the normal the yield has averaged 33 bushels per acre.

TABLE 17.—*Correlation of rainfall in July and the yield of corn for Ohio, Indiana, Illinois, Iowa, Nebraska, Kansas, Missouri, and Kentucky.*

Year.	July rainfall.			Corn yield.			3×6
1	2	3	4	5	6	7	8
	Amount.	Departure.	Square of departure.	Amount.	Departure.	Square of departure.	
	Inches.	*Inches.*		*Bushels.*	*Bushels.*		
1888	3.6	−0.3	0.09	32	+ 2	4	− 0.6
1889	4.9	+1.0	1.00	33	+ 3	9	+ 3.0
1890	2.1	−1.8	3.24	23	− 7	49	+12.6
1891	3.6	−0.3	.09	32	+ 2	4	− 0.6
1892	3.8	−0.1	.01	28	− 2	4	+ 0.2
1893	3.0	−0.9	.81	26	− 4	16	+ 3.6
1894	1.6	−2.3	5.29	20	−10	100	+23.0
1895	4.2	+0.3	.09	31	+ 1	1	+ 0.3
1896	6.4	+2.5	6.25	34	+ 4	16	+10.0
1897	3.6	−0.3	.09	26	− 4	16	+ 1.2
1898	3.5	−0.4	.16	29	− 1	1	+ 0.4
1899	3.8	−0.1	.01	30	+ 1	1	− 0.1
1900	4.6	+0.7	.49	31	+ 1	1	+ 0.7
1901	2.0	−1.9	3.61	18	−12	144	+22.8
1902	4.8	+0.9	.81	34	+ 4	16	+ 3.6
1903	3.8	−0.1	.01	29	− 1	1	+ 0.1
1904	4.4	+0.5	.25	30	+ 0.3	....	+ 0.2
1905	4.9	+1.0	1.00	35	+ 5	25	+ 5.0
1906	3.8	−0.1	.01	36	+ 6	36	− 0.6
1907	5.1	+1.2	1.44	30	+ 0.5	....	+ 0.6
1908	3.6	−0.3	.09	29	− 1	1	+ 0.3
1909	5.1	+1.2	1.44	31	+ 1	1	+ 1.2
1910	4.2	+0.3	.09	32	+ 2	4	+ 0.6
1911	2.8	−1.1	1.21	30	− 0.1	....	+ 0.1
1912	4.1	+0.2	.04	34	+ 4	16	+ 0.8
Sums	97.3	....	27.62	....	....	466	+88.4
Means	3.9	....	....	....	....	....	....

This means that when the rainfall for July averages less than 3.4 inches, the yield of corn over these eight States will average 10 bushels to the acre less than when the rainfall is more than 4.4 inches.

This is a difference of 500,000,000 bushels in the total yield of corn, and when corn is worth 50 cents per bushel the purchasing power of the farms in the central part of the United States is increased $250,000,000 through corn alone. Surely, corn is king.

Discussion of figures.

Each figure is explained by its head and legend. It will be well, however, to call attention to the fact that in Iowa and South Dakota the mean date of the beginning of corn harvest as shown by figure 9 is later than the average date of the first killing frost, as indicated in figure 7. In most other districts the corn harvest begins before killing frosts.

It would seem, therefore, that in calculating the length of the growing season to be from the date of planting to the date of harvesting we are considering too long a growing season in Iowa and South Dakota. This seems to be shown in the large number of growing days in figure 10, too high thermal constants in figure 11, too great an amount of rainfall in figure 13, and too great a number of possible hours of sunshine as shown in figure 14, in that particular district as compared with surrounding States.

This is particularly brought out in figure 12 by the low daily thermal constants in Iowa, especially as compared with other sections. It is quite probable that the end of the season should have been the average date of the first killing frost in the autumn, but inasmuch as the dates of beginning of planting and the beginning of harvest were used in other States, we have thought best to use the same data throughout.

In figure 15 the effect of the Great Lakes in causing an increased amount of cloudy weather is well shown.

In connection with these thermal constant and sunshine charts, reference should again be made to the sunshine-hour degree differences as stated on page 78 of this article. The whole study of thermal and sunshine constants is a most important one and can profitably be carried out more in detail.

CONCLUSIONS.

1. The controlling weather factor in the great corn-growing districts of the United States is rainfall.
2. The critical period of growth of corn during which favorable weather will cause a large crop and unfavorable weather a short crop, is comparatively brief.
3. If the rainfall for calendar months be considered, that for July has a far greater effect upon the corn yield than rainfall for any other month.
4. The rainfall from about the middle of July to the middle of August has a far greater effect upon the corn yield than that for any other period of similar length.
5. The rainfall for the 10 days following the date of blossoming has an almost dominating effect upon the yield of corn, the larger the rainfall the larger the yield.
6. If the rainfall is small during the 10 days after blossoming a high temperature has a very unfavorable effect upon the yield.
7. Rainfalls of one-half inch or more have a greater effect upon the development of corn than falls of less amount.
8. It seems possible to give a close estimate of the probable yield of corn by August 10, by careful study of the weather conditions that have prevailed up to that time.
9. The importance of shallow cultivation after each rainfall in July, and after August 1 for the purpose of forming a dust mulch and thus preventing the loss of water by evaporation, can not be overestimated.
10. The science of agricultural meteorology can be advanced, and the results of these investigations be made of more practical value to the farmer, by a detailed study of the critical periods of growth and the weather factors most affecting the yield of other field and garden crops.

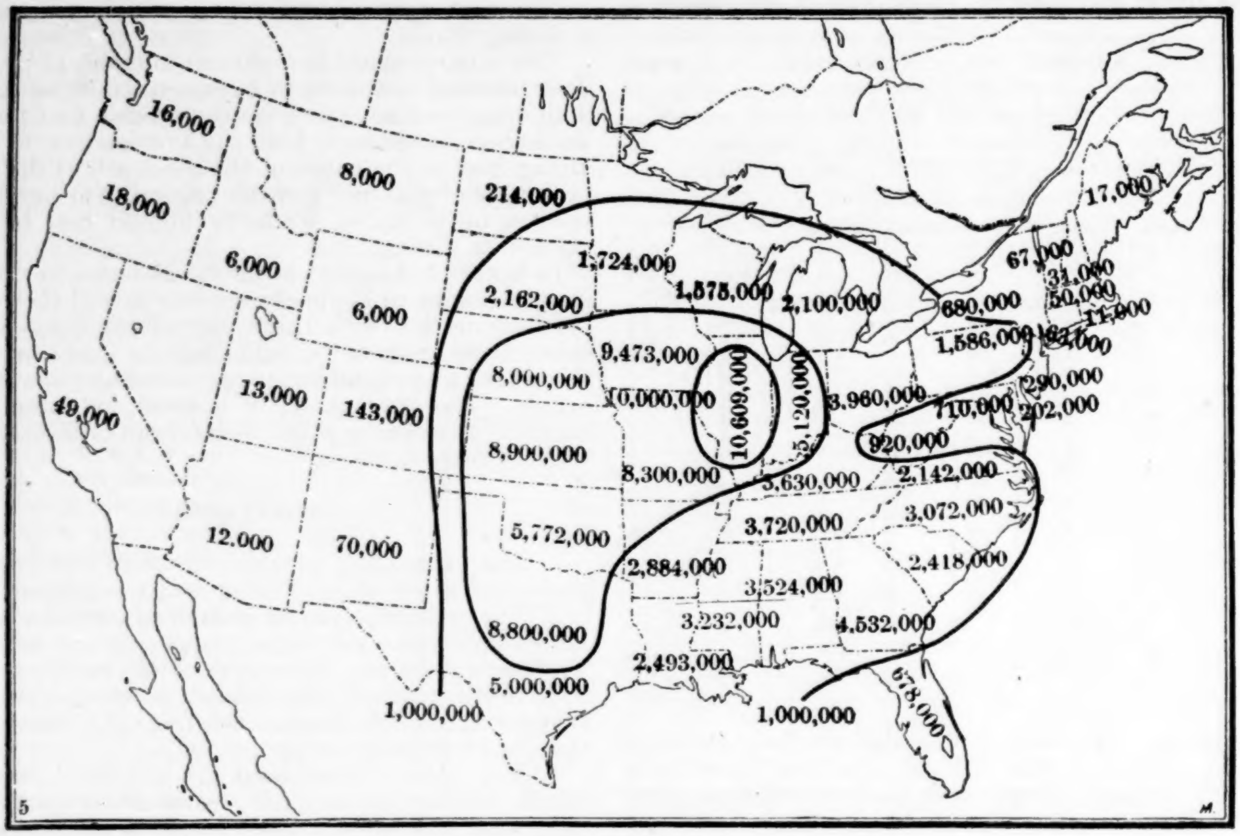


FIG. 5.—Number of acres planted to corn in each State in 1910.

FIG. 6.—Average date of last killing frost in spring. (From Weather Bureau Bulletin V.)

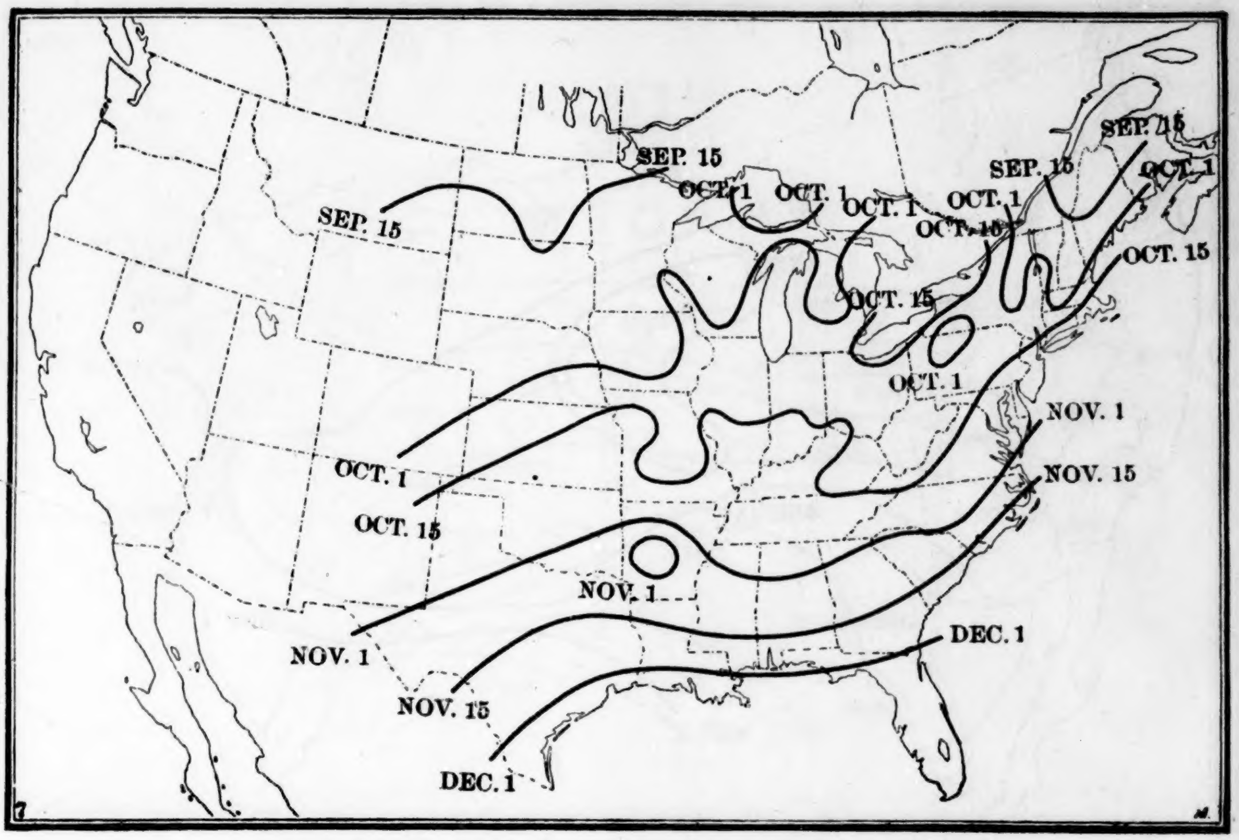


FIG. 7.—Average date of first killing frost in autumn. (From Weather Bureau Bulletin V.)

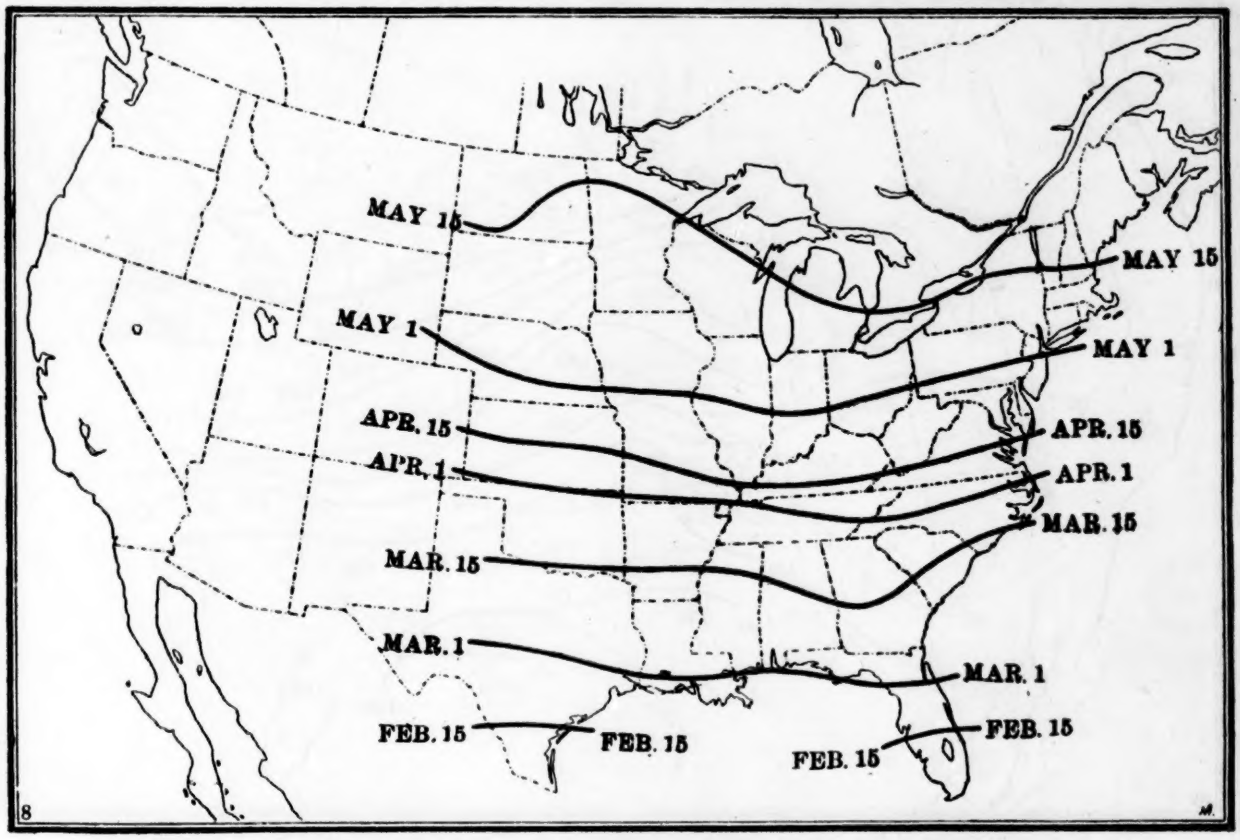


FIG. 8.—Average date when corn planting begins. (From Bureau of Statistics Bulletin 85.)

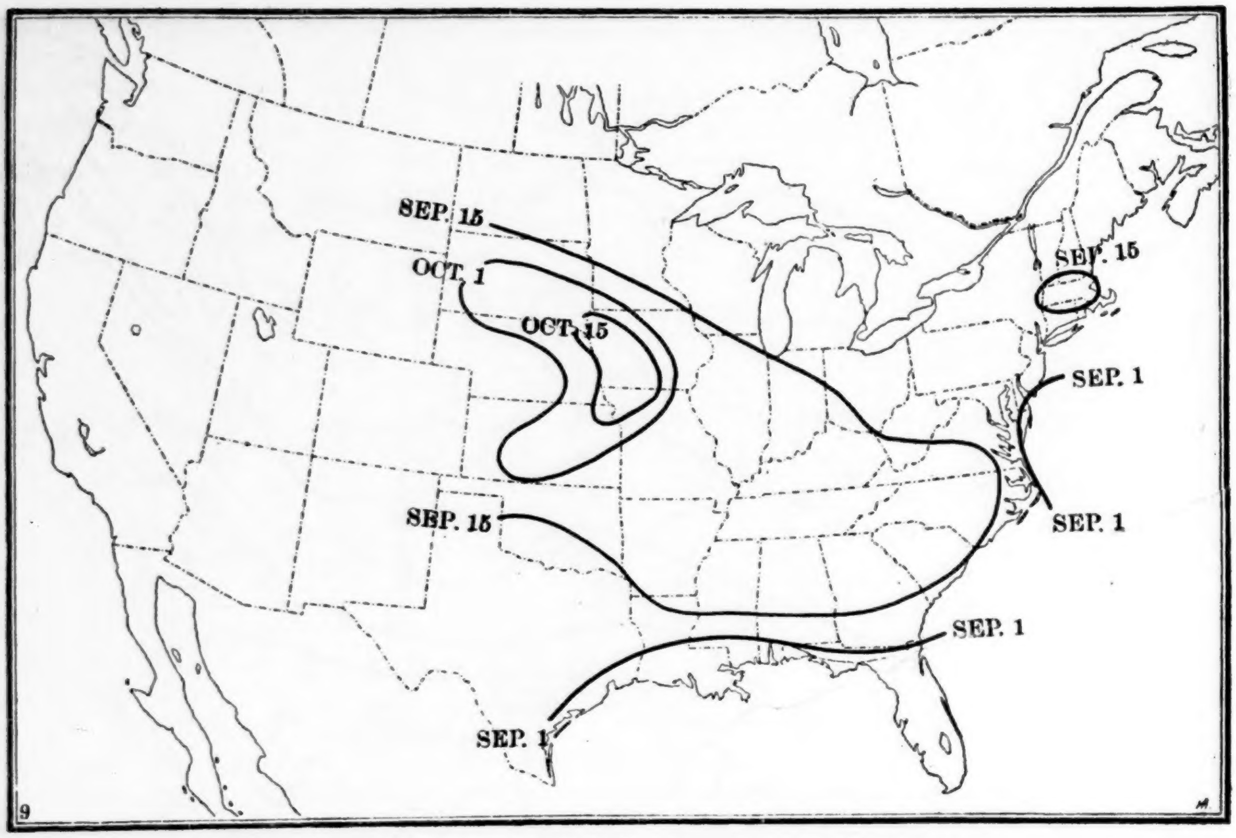


FIG. 9.—Average date when corn harvesting begins. (From Bureau of Statistics Bulletin 85.)

FIG. 10.—Average number of days between planting and harvesting corn. Figures show averages for the whole of each State.

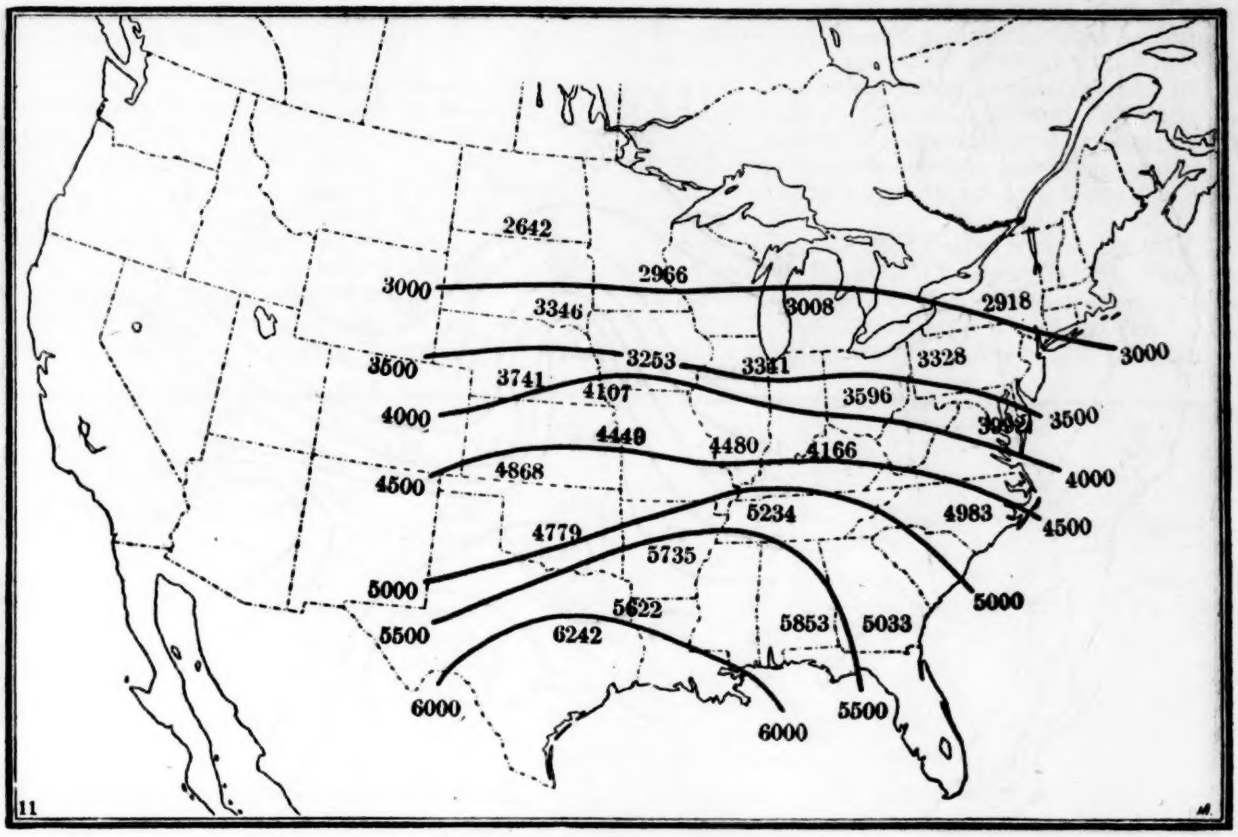


FIG. 11.—Average thermal constants between planting and harvesting corn. Figures show sums of daily mean temperatures above 43° F. during growth and maturing of the corn plant.

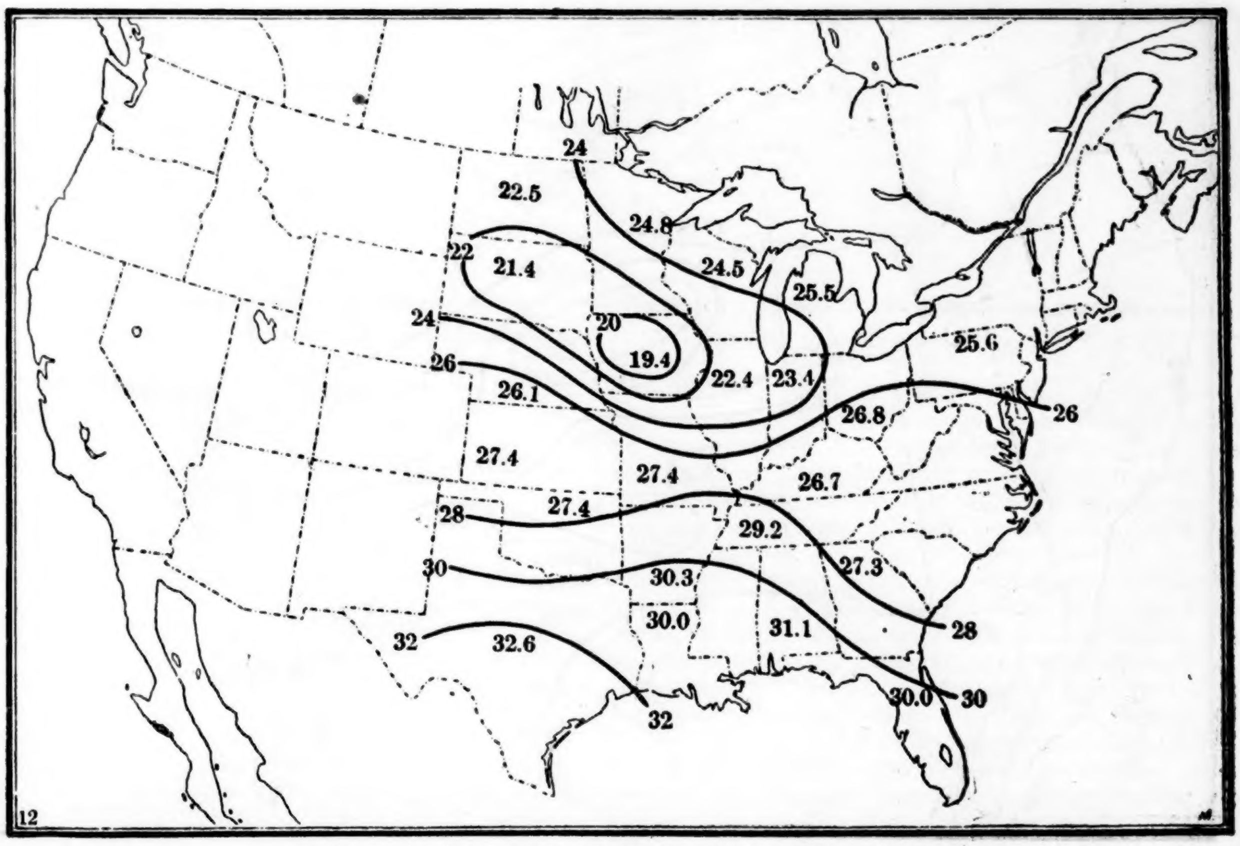


FIG. 12.—Average daily thermal constant between planting and harvesting corn.

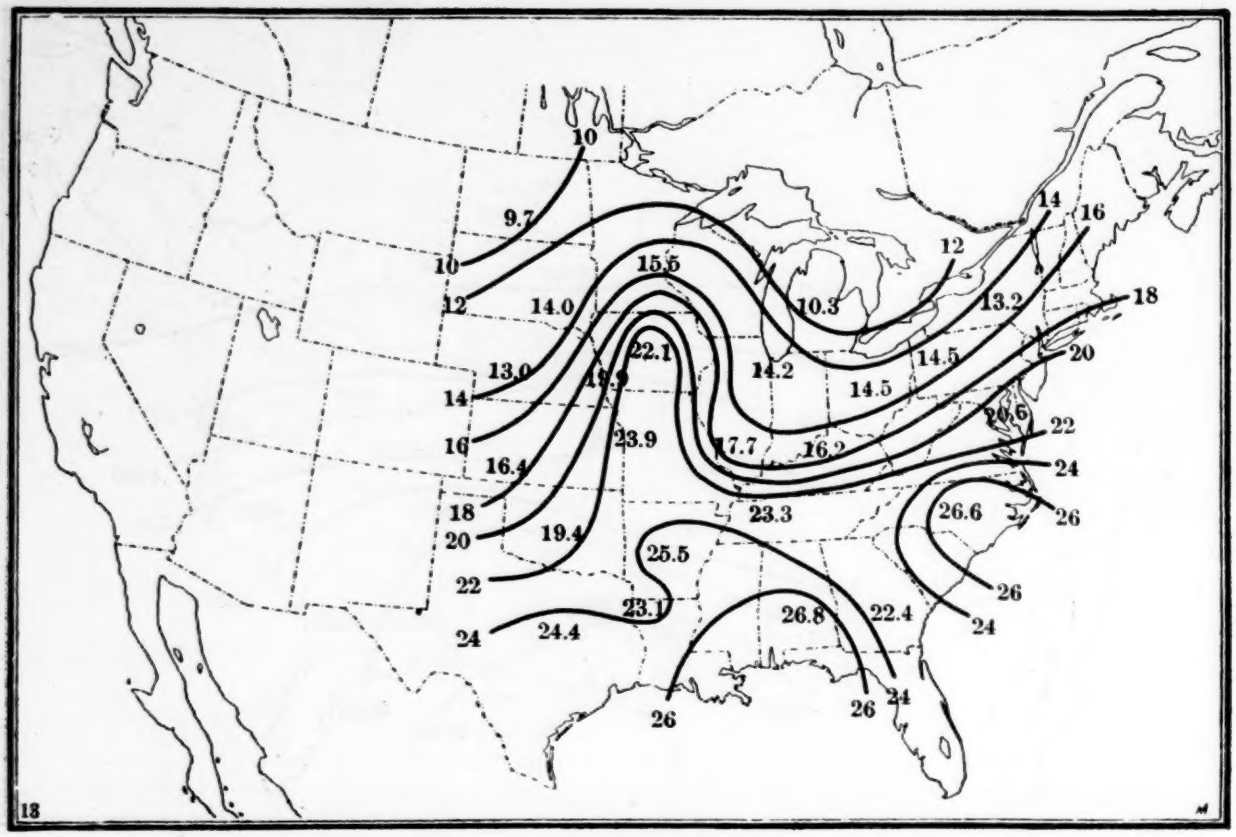


FIG. 13.—Rainfall constants from planting to harvesting of corn. (Average total rainfall during the growth and maturing of the corn plant.)

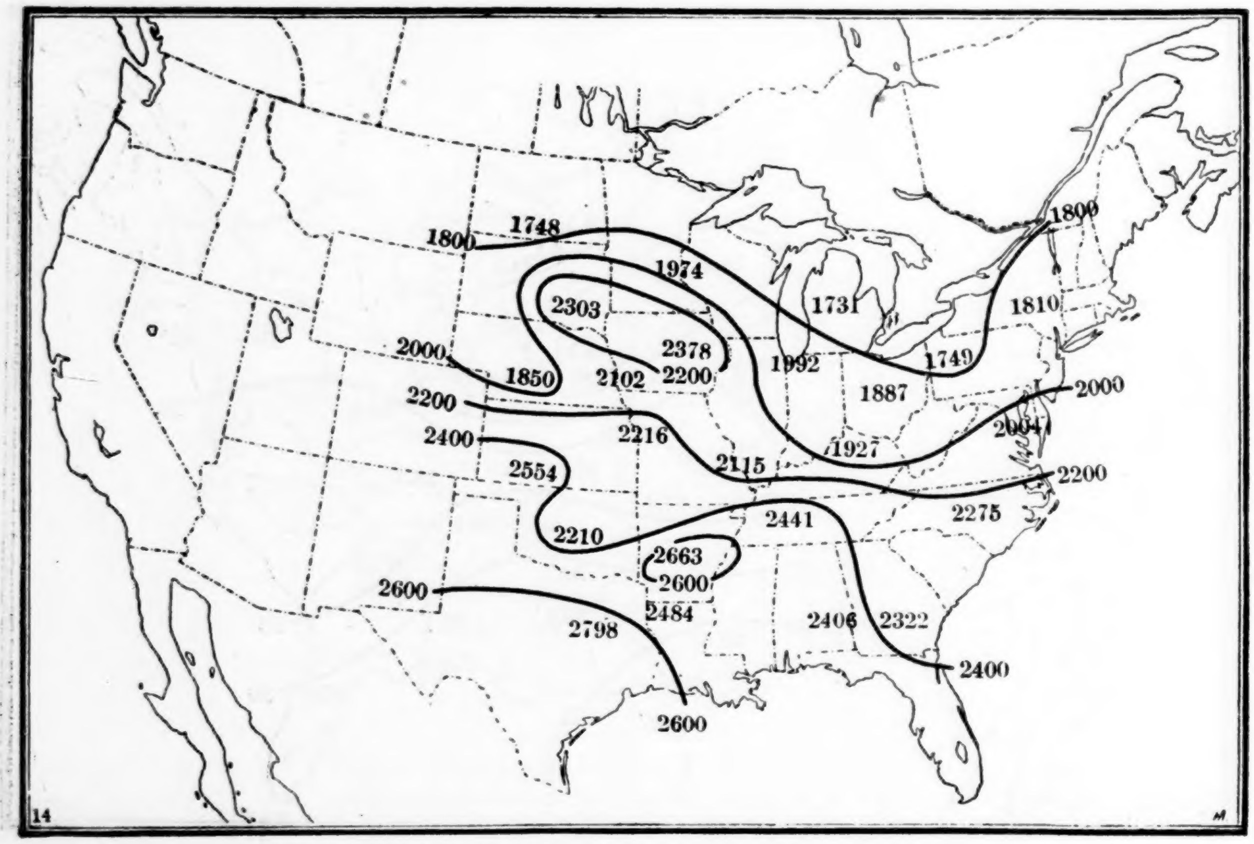


FIG. 14.—Total possible hours of sunshine between planting and harvesting of corn.

UNPUBLISHED CONTRIBUTIONS TO THE INTERNATIONAL METEOROLOGICAL CONGRESS HELD AT CHICAGO, AUGUST, 1893.

Although Prof. M. W. Harrington originally contemplated publishing all the important contributions offered to the International Meteorological Congress, which met at Chicago, Ill., August 21-24, 1893, yet that work progressed very slowly, owing to the absence of any special provision for the expense; and the preparation for publication almost entirely ceased in 1897 after printing Parts 1, 2, and 3 as the first eight sections, i. e., pages 1-772 of United States Weather Bureau Bulletin 11.

As the years passed, the preparation of the remaining sections 9 and 10, which would have formed Part 4 of Bulletin 11, progressed so slowly that Prof. W. L. Moore relinquished the plan of completing that bulletin.

It is believed that many of these unpublished papers still retain their value, either as contributions to Dynamic Meteorology or to Climatology, and especially as illustrating the status of meteorological science in 1893. It has therefore been decided to publish them when practicable in future numbers of the MONTHLY WEATHER REVIEW.

The following communication by the late Prof. H. Wild, of the Central Physical Observatory, St. Petersburg, is now presented because of its historical interest in connection with the daily Map of the Northern Hemisphere noticed in the REVIEW for January, 1914.—[C. A.]

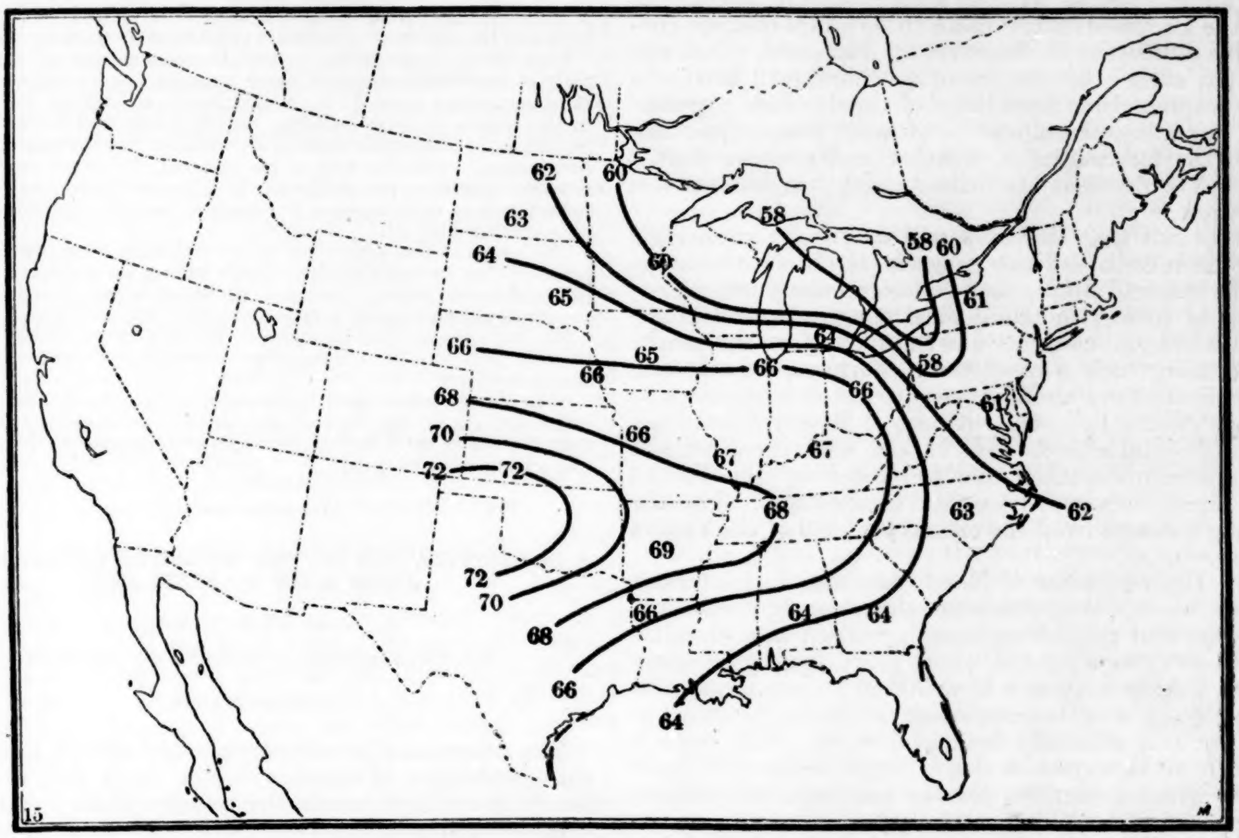


FIG. 15.—Percentage of possible sunshine between planting and harvesting of corn.

ON THE THEORETICAL AND PRACTICAL IMPORTANCE OF A SERIES OF DAILY WEATHER CHARTS OF THE NORTHERN AND SOUTHERN HEMISPHERES.

[Communicated to the International Meteorological Congress at Chicago, August, 1893.]

By Prof. Dr. H. WILD.

[Dated St. Petersburg, 28 June, 1893.]

In a letter dated February 10, 1893, Prof. Cleveland Abbe has asked me to prepare for presentation to this Meteorological Congress, a general statement of "The theoretical and practical importance of a series of daily weather maps of the Northern and Southern Hemispheres, as complete as they may be made through the cooperation of all nations; the series to be in continuation of the maps of the Northern Hemisphere formerly published by the United States. Also to consider certain details, such as the character of the projection to be used, the reduction to normal gravity, to sea level, the observation hours, etc."

When I declined to prepare such a report, because of lack of time, Prof. Abbe again wrote under date of May 25, urging me to present at least in brief my views on this subject. In consenting to this last request, I must again ask that should this response appear rather elementary, allowance be made for the very limited leisure at my disposal.

Certainly no meteorologist will dispute the theoretical importance of daily synoptic weather maps for the whole globe, so far as this is accessible to observation. It will also be universally conceded that barometric readings from such a map should be reduced to sea level, and that only simultaneous observations can be used thereon. Both the directly observed temperatures and their departures from the respective normals should be plotted. In other regards the elements formerly published in the Bulletin of International Simultaneous Observations, at Washington, would suffice for the present. Since continued observations within the polar circles are but occasional and

at scattered places, the Mercator projection may be recommended for these synoptic charts, with the possible addition of supplementary maps in polar projection for special occasions. In any case there will surely be no one to prefer the wholly unsuitable projection adopted, for example, for the Chart of Annual Rainfall in Berghaus' Physikalisches Atlas, 1887 edition, wherein the greatest distortion occurs in the Temperate Zones, the very region of which we know the most.

From the theoretical viewpoint the one daily simultaneous observation may be made at any hour; practically Greenwich noon would probably be the best time, since then the late afternoon and the early morning hours, which are the most difficult to secure in simultaneous observations, almost without exception will fall to the lot of the Pacific stations where these hours offer no considerable difficulties to observers on shipboard. It is evident that such extensive synoptic charts will further a more comprehensive knowledge of the dynamic phenomena of our atmosphere, and be of great practical advantage in the forecasting of weather and storms; thus it would not be necessary to make special provision for this latter work.

I doubt not that this view will find warm supporters among the members of this congress, but if it is to emerge from the realm of simple desire where so many unanimous resolves of former meteorological congresses still abide, then this Chicago congress must also consider the means for executing such a resolution. Perhaps, indeed, such arrangements have already been perfected very much as when at Vienna Brig. Gen. Albert J. Myer initiated the system of simultaneous observations over the Northern Hemisphere, undertaken and published by the United States Signal Service, whose chief he then was. [See the following extracts from the official protocol of the Vienna congress.—C. A.]

If the United States of North America, in its former generous manner, shall guarantee the means for collecting, discussing, and publishing these proposed new simultaneous observations for the whole globe, it may be safely assumed that no nation will withhold its cooperation in organizing the simultaneous observations in its own territory for this mutually beneficial work. But since it is scarcely to be expected that a single nation will again make so great a sacrifice for the international welfare, the proposed undertaking can only be realized by assigning its execution to an international meteorological bureau founded and maintained at the expense of all nations. The establishment of such an international bureau, but for other purposes, was discussed at the International Meteorological Conference at Munich in 1891, and referred to the International Meteorological Committee for further consideration. The congress at Chicago might therefore request the latter committee to consider the present question as an additional task for such an international meteorological bureau.

[Extracts from Bericht über die Verhandlungen des Internationalen Meteorologen-Congresses zu Wien, 2.-16. September, 1873. Protokolle und Beilagen. Wien. 1873. vi., 114 p. 4°.]

PROTOCOL OF THE SEVENTH SESSION, SEPTEMBER 12, 1873, 10:20 A. M.

Chairman: Mr. SCOTT.

After the minutes of the sixth plenary session were read and approved, the chairman read the written proposition, published as First Appendix to Protocol No. 7, from Delegate General Myer, concerning the institution of at least one daily simultaneous observation, and announced that the discussion of this proposal had been assigned to the next session. (Pp. 23-24.)

1. BEILAGE ZUM PROTOKOLL DER VIIten SITZUNG. LETTER OF GENERAL ALBERT J. MYER TO THE CONGRESS.

METEOROLOGICAL CONGRESS,
Vienna, September 11, 1873.

To the Congress.

GENTLEMEN: I have the honor to submit the following proposition: [1]

"That it is desirable that with a view to their exchange at least one uniform observation of such character as to be suitable for the preparation of synoptic charts be taken and recorded daily and simultaneously at as many stations as practicable throughout the world."

I am, gentlemen, very respectfully,

(Signed) ALBERT J. MYER,
Brigadier General, Chief Signal Officer, U. S. A.

PROTOCOL OF THE EIGHTH SESSION, SEPTEMBER 13, AT 10.35 A. M.

* * * Next came the discussion of the proposal made by Gen. A. Myer (introduction of simultaneous observations over the whole Northern Hemisphere, appendix 1 to protocol of the seventh session).

First, Mr. Myer stated that he was commissioned by the War Department of the United States of North America to assure the congress of the deep interest taken by the department in all that concerns advance in the system of storm warnings and its desire that the exchange of international telegraphic weather reports shall find the greatest possible distribution. Turning then to his proposal, Mr. Myer stated that it seemed superfluous to argue for the actual establishment of it since the importance of simultaneous observations would undoubtedly be at once conceded by all.

The proposal was supported on several sides. Mr. Hoffmeyer announced that he could support it only in case no very great practical difficulties were present, because it could not be held that the scientific results would justify any very great sacrifice for their sake.

Mr. Buys-Ballot drew attention to his own "Suggestions," wherein he had pointed out simultaneous meteorological observations as a desirable object.

After Mr. Myer had again emphasized the fact that his proposal only called for a declaration by the congress that simultaneous observations over the whole earth were a desirable consummation, the resolution was unanimously adopted. * * * (P. 27.)

A CLASSIFICATION OF THE METHODS OF TRANSITION FROM RAIN TO BLUE SKY.

By Prof. WILLIS I. MILHAM.

[Dated Williams College, Williamstown, Mass., Feb. 20, 1914.]

INTRODUCTION.

The occurrence of rain or snow and also of most of the thundershowers of summer is due, as is well known, in nearly every instance to the passage of an extratropical cyclone or area of low barometric pressure near the place in question. Rain or snow now and then result from a V-shaped depression, or from an overgrown cumulus cloud, or from the action of a barrier, or from the condensation of moisture from a purely local source, and summer thundershowers are also sometimes due to purely local conditions, but these cases are too few in comparison with the whole number to merit further consideration. In winter, a passing low is generally attended by a continuous fall of rain or snow for some hours. In summer, warm, sultry weather with thundershowers, particularly in its southern quadrants, is the usual accompaniment of a passing low.

The distribution of the meteorological elements (temperature, pressure, wind, moisture, cloud, precipitation) about an area of low pressure has been much studied by many observers, and the statistical method has been the usual way of studying these formations. Most of the books on meteorology contain in more or less detail the generalizations from these statistics, which may be

[1] Adopted at the VIIIth Session, Sept. 13, 1873 (p. 58.)

expressed as laws, in tables, or by means of diagrams (1). The distribution of the meteorological elements about a low is not exactly the same for all countries or for all parts of the same country and there is also a difference depending upon the seasons. Thus the geographical and seasonal changes ought to be studied as well as the distribution itself. But the differences are not large as a low is very much the same formation the world around.

The sequence of cloud forms before, during the intervals between, and after rains has also been much studied. The work of the Blue Hill Observatory near Boston is particularly worthy of mention, and an article by Clayton in the Annals of the Harvard College Observatory, Volume XXX, treats this question in detail. This, to be sure, is only one phase of the general question of the distribution of the meteorological elements about a low, but the change in cloud forms and their direction of motion, the occurrence of rain or snow, and the direction of the wind are the factors which can be observed without instruments and are the most conspicuous and interesting in the sequence of events which accompany the passing of a low.

It is the distribution of the elements about a *normal* or *typical* low and the *normal* or *usual* sequence of cloud forms which is determined by these statistical investigations. If every low were normal, the sequence of events in passing from rain to blue sky would always be the same. Any observer of weather changes knows that this is not the case, and the reason is that lows almost never conform exactly to the normal or type form. The question treated in this paper is whether the methods of transition from rain to blue sky can be classified in different ways, so that by stating in which group a low belongs, its characteristics are at once apparent to anyone familiar with the various types.

I. GRADUAL SHIFT VERSUS RAPID SHIFT.

The first great difference between lows is whether, as one passes through the southern quadrants, there is a gradual veering of the wind from some easterly quarter into the northwest, or whether the change is almost instantaneous. In the first case the sequence of events is usually as follows: At first the wind begins to blow gently from the east, the pressure decreases slightly, cirrus clouds make their appearance, and the temperature and moisture begin to increase. Next, the barometer drops a little more, the wind direction changes to the southeast and the velocity becomes a little greater, the cirrus clouds thicken to cirro-stratus or cirro-cumulus, and the temperature and moisture continue to rise. In the wintertime, as the popular phrase goes, the weather has begun to moderate. In the summertime it is the beginning of a period of sultriness. The pressure now drops still more, the wind veers a little and blows harder, the cirriform clouds go through their regular transition into nimbus, and the temperature and moisture are high and increasing. Now comes a period of rain or snow, with barometer still dropping and finally reaching its lowest. The wind, meantime, has slackened somewhat and veered a little, and is perhaps now blowing fiom the south or southwest. The temperature and moisture still continue high. The wind now veers rather quickly into the southwest, then west, and finally northwest. The barometer begins to rise, the precipitation grows less, and the temperature and moisture decrease. Soon the nimbus clouds break up into fracto-nimbus, perhaps disclosing an upper cloud area. The fracto-nimbus then changes into strato-cumulus, and finally cumulus or fracto-cumulus, with a clear sky at night. In the meantime the wind blows from the northwest with increasing velocity, the barometer is rising, and the temperature drops rapidly. The air also becomes much drier. In the summer the dry, cool, northwest wind has replaced the oppressive sultriness of a few days before. In the winter the thaw or warm spell has been replaced by a cold snap.

If, on the other hand, the windshift is very sudden, the low possesses what may be called a wind-shift line, and the sequence of events is then somewhat different. The coming of the rain or snow is just as before, but the wind ceases to veer and remains from the south or some southerly quarter. The rain or snow usually ceases for a time, and the lower nimbus cloud layer usually bieaks in places or entirely disappears, leaving an upper layer of cirriform or alto clouds. The temperature and moisture remain high. Soon the black bank of cloud begins to appear all along the western horizon and then mounts higher and higher. In a moment the wind snaps into the northwest and blows with considerable velocity. A squall of snow or a heavy fall of rain, perhaps with thunder and lightning, commences, and the temperature drops as if by magic. Soon the precipitation ceases, the lower cloud layer breaks up, and the sequence of events is as before.

In the United States about one low in seven is accompanied by this sharp wind shift. In Europe it is said to be much more common. Its cause is probably the way in which the weather control is transferred from the passing low to the coming high. A coming high has on its front masses of cold air from the northwest. These either overrun or underrun the warm, moisture-laden air of the low and thus cause a rolling of the air about a long, horizontal axis, and to this is due the sudden wind shift. If the replacement of the warm, moist air by the colder air from the northwest is a more gradual process, a low of the first kind is the result.

The two accompanying diagrams (Figs. 1 and 2) show the distribution of the meteorological elements about these two kinds of lows. The solid lines are isobars, or lines of equal pressure; the dashed lines are isotherms, or lines of equal temperature. The wind direction and velocity are indicated by the direction and length of the arrows. The cloud forms on the east are first cirrus, then the transition clouds, and finally nimbus, which breaks up on the west usually into strato-cumulus. By moving these diagrams slowly from left to right, so that a place passes through their southern quadrants, the sequence of meteorological events due to the passage of such lows becomes at once evident.

II. THE THREE TYPES OF GRADUAL WIND SHIFT.

In the first of the preceding cases, when the wind veers gradually and continuously from some easterly direction until it finally reaches the northwest, it is of importance to note the direction of the cloud motion as compared with that of the surface wind. While it is raining both clouds and wind usually come from the same easterly or perhaps southerly quarter. When the wind finally reaches the northwest and blue sky has appeared, the clouds generally come from the northwest as well. During the shifting, however, the cloud direction and the wind direction may not coincide. The direction of cloud motion may shift with the wind, it may be ahead of it (that is, come from a more westerly quarter), or it may be behind it. There are thus three possibilities. If diagrams (Annals of the Harvard College Observatory,

Vol. XXX) showing the distribution of the meteorological elements about a low at various levels above the earth's surface are examined, it will be seen that normally the cloud motion should be ahead of (more westerly than) the wind direction. Theory also shows that this is the expected result. Statistics will show that this is true in about six cases out of ten. In perhaps two cases the direction will be coincident and in perhaps two cases it will lag behind. The reason is twofold. In the first place, the masses of cooler air accompanying the advancing high and coming from the northwest either overrun, or underrun, or mingle with the moist, warm air accompanying the departing low and coming from a more southerly direction. If the air underruns, the surface wind will shift before the clouds; if it overruns, the clouds will shift ahead of the wind; if there is mixture, it is doubtful just which case might result. In the

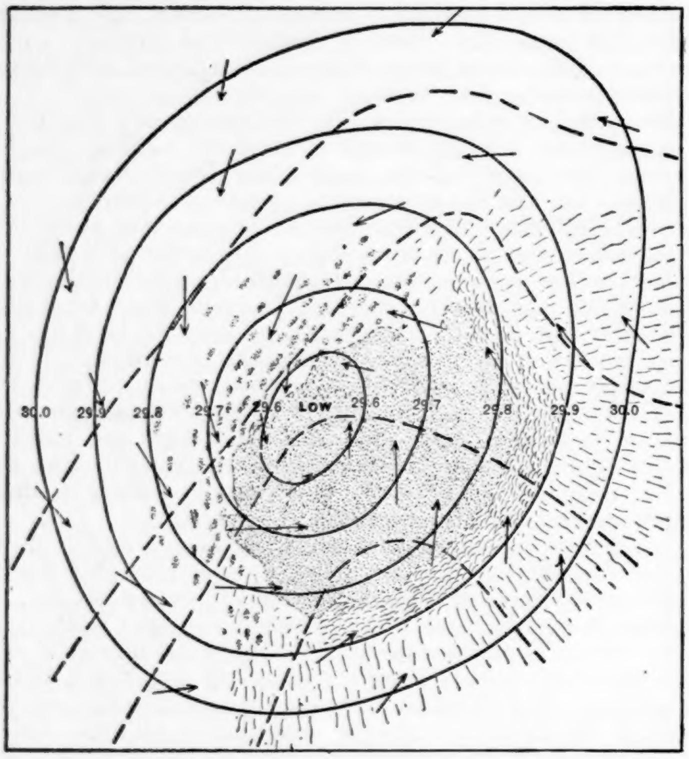


FIG. 1.—Conditions attending a gradual slow change of wind and weather.

second place the axis of a low leans backward or westward. By the axis is meant a line joining the successive centers of lowest pressure at various heights above the earth's surface. At first thought one would expect this to be perpendicular to the earth's surface, but the unequal temperature distribution on the two sides of a low causes the axis to lean backward or westward. It is well known that on a high mountain the center of a low sometimes passes an hour or so later than at the earth's surface. This leaning back of the axis will also influence the relation between the wind direction and the direction of cloud motion. The amount of the leaning is not the same for all lows, but depends on the temperature distribution about the low in question.

III. ONE CLOUD LAYER OR MORE THAN ONE.

When the lower cloud layer finally breaks through and discloses the blue sky, an upper cloud layer may be seen or there may be none. Sometimes more than one layer is glimpsed. It consists usually of cirriform or alto clouds which move from a more southerly direction than the lower clouds and usually disappear in a few hours. According to the Blue Hill observations, in 110 cases upper layers were seen 74 times. The ordinary observer who does not make many observations at night and who is not constantly on the lookout for the merest trace of an upper layer will not see as many. He will be of the opinion that not more than one low in three or four has an upper layer. The upper layer is perhaps more common after a rapid wind-shift low than after one in which the wind veers gradually.

IV. THE RAPIDITY OF CLEARING OFF.

After the rain ceases, the blue sky may appear quickly, after the normal time, slowly, or it may remain totally

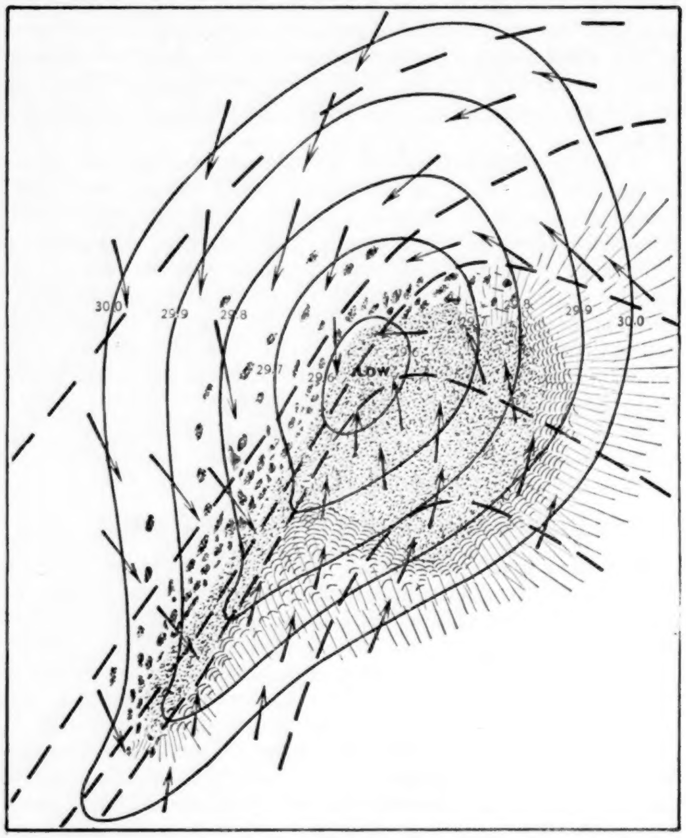


FIG. 2.—Conditions attending a sudden change of wind and weather.

cloudy until it rains again. The normal time interval between the ending of the rain and the first blue sky is perhaps four or five hours. Sometimes it may appear in an hour or two, in which case it has cleared very quickly. The clouds may last 12 hours or a whole day, in which case it has cleared very slowly. There are a few cases where it will remain totally cloudy until it rains again. The second rain must occur, however, at least 24 hours after the stopping of the first to be considered an independent, separate storm.

V. FURTHER CLASSIFICATIONS.

If simple instruments, such as a thermometer and barometer, are available, a few additional but perhaps less interesting classifications may be made. The lowest pressure usually occurs when the wind is from the southwest. Lows may be classified as wind in the southwest, wind more easterly, or more westerly when the pressure

is lowest. The temperature drop after the rain ceases and the blue sky comes may also be noted. This can be classified as small, normal, or large. The rapidity or rise of the barometer may also be classified as rapid, normal, or slow.

VI. LIMITATIONS.

This classification of the sequence of events in passing from rain to blue sky applies geographically to New England or the Middle Atlantic States. This normal distribution of the meteorological elements about a low is, however, but slightly different for any part of this country and not very different for the Atlantic Ocean or for Europe.

Furthermore, it has always been a low which so moves that an observer passes through its southern quadrants, that has been considered. Now for the northwestern part of the United States this is nearly always the case. A wind that backs instead of veers is very unusual except possibly near the seacoast and in the extreme northern part. The sequence of events would be entirely different, and this has not been considered.

Furthermore, it is the winter type of storm with steadily falling rain or snow which has been considered rather than the summer type with the sultry weather and thundershowers. The best way to characterize the difference between the summer and winter type is to liken it to a machine. In the winter type the machine runs smoothly. In the summer type the machine clogs and stops and then by a thundershower is jerked forward to where it ought to be. The sequence of events goes forward by jerks rather than smoothly.

Furthermore, exact figures have not been given. It would require ten years of careful observation to do this, and but little would be gained. The value is in the classification. For example, it makes little difference whether about one low in seven has a sharp wind-shift line or it is finally found that for a definite place for a definite period of ten years it is exactly 17 per cent. This classification is based upon two or three years of casual observation and one year of critical observation to test the classification at Williamstown, Mass.

VII. SUMMARY.

As was stated at the beginning, the purpose of this article is to attempt a classification of the various methods of transition from rain to blue sky. For example, it may be said of a certain passing low which caused the rain, that the wind veered steadily instead of changing suddenly; that the direction of the cloud motion was ahead of the wind direction; that an upper cloud layer was seen for a short time; that the time required for showing blue sky was normal. It might also have been stated that the lowest pressure came with the wind from the southwest, that the temperature drop was normal, and that the pressure increase was rapid. It will thus be seen that this classification would give to anyone familiar with the various methods of transition, a definite picture of the characteristics of the passing storm. It will also add much pleasure to watching this oft occurring transition to know the various ways in which it may take place and the one in progress in the instance under observation.

REFERENCES.

(1) See: Annals of Harvard College Observatory, Vol. XXX.
Hann, Julius. Lehrbuch der Meteorologie. Leipzig, 1901; 2d ed., 1905; 3 ed., 1914. 4°.
Hanzlik, Stanislav. Die räumliche Verteilung der meteorologischen Elemente in den Antizyklonen. Wien, 1898. 94 p. f°.
Hanzlik, Stanislav. Die räumliche Verteilung der meteorologischen Elemente in den Zyklonen. Wien, 1912. 62 p. f°.
Meteorologische Zeitschrift, Braunschweig. Juli, 1903. v. 20. p. 307.
Milham, Willis I. Meteorology. New York, 1912. 8°.

SQUALLS AND THE PREDICTION OF TORNADOES.

By E. DURAND-GRÉVILLE.

[Dated Paris, Mar. 30, 1913. Translated for the Monthly Weather Review.]

INTRODUCTORY NOTE.

The International Conference of Directors of Meteorological Observatories, which met at Innsbruck, Austria, in September, 1905, listened to an enthusiastic paper on the phenomena of squalls by M. E. Durand-Gréville. After his address Prof. H. Hildebrandsson suggested that the conference appoint a commission on squalls, its functions to be analogous to those of the International Commission on Clouds appointed by the International Meteorological Committee. Favorable action by the Conference resulted in the appointment of such a Commission composed of MM. Hildebrandsson (Upsala), Shaw (London), and Durand-Gréville (Paris).

M. Durand-Gréville was long an active student of squall phenomena, and this REVIEW has already published an exposition of his discoveries in this branch of meteorology. The publication of the present paper has been delayed by administrative changes that were impending at the time of its receipt. The Editor regrets to announce the death of its author on January 20, 1914.

SQUALLS.

What has come to be known as the "law of squalls" did not present itself to my mind at one time. Several years previous to 1890, being intrusted with the meteorological articles in the Grande Encyclopédie, I had first made myself acquainted with the earlier works, or at least with the greater number of them, notably with those of Ciro Ferrari, who, according to the expression of Hildebrandsson, was "the one who had done the most" for the knowledge of thunderstorms; also, of course, the works of Marié-Davy, written under the direction of Le Verrier.

The latter had given the simplest possible definition of a thunderstorm, viz, "any disruptive electrical discharge in the atmosphere." The definition had become complicated little by little, in proportion as the details had been studied and various brusque changes at the time of the thunderstorm had been observed, such as rise of the barometer; increase in force and change of direction of the wind; fall of temperature; increase of relative humidity, etc. I shall tell you why it seems necessary to revert to the original definition of the thunderstorm and to restore to the squall its personality, the squall serving only—as occasional cause—to rouse up the thunderstorm *at the moment* when it arrives from a distance on large cumuli previously formed.

In studying attentively the thunderstorm isochrones of Marié-Davy and more especially those of Ferrari, I perceived that there appeared to be a real correspondence between two "thunderstorm spots" not too far distant from one another and that, in certain cases, the isochrones of the two "spots" could easily be connected. If one sought to verify what took place between the two "spots," one would discover the existence of a wind squall, of a barometric "hook" (crochet), etc. This work of verification was done slowly and fragmentarily, but in the end I was persuaded—without, however, having any very tangible proof of it—that the isochronous line of a violent squall passing over a place in the morning without evoking a thunderstorm, would continue its

course toward the east, until the time—especially in the afternoon—when it would rouse a thunderstorm at points properly prepared for it.

Chance furnished me with a sort of *a posteriori* proof of this. On August 27, 1890, I had witnessed a very violent squall which passed over Angers just before midday, unaccompanied by thunderstorm, rain, hail, or even cloudiness. The first observatory that I was able to communicate with was that of La Baumette, 5 kilometers from Angers. I found there all the phenomena of pressure, force and direction of wind, and temperature that I had expected. I noted the time of beginning, maximum, and end of all these phenomena and made copies of the tracings or had them photographed. The same was done for the other observatories in the neighborhood and afterwards for all those in Europe, and I thus obtained proof that the squall occurred at a given instant over a length of more than 1,200 kilometers, and formed a narrow band oriented north-south, which moved with a uniform

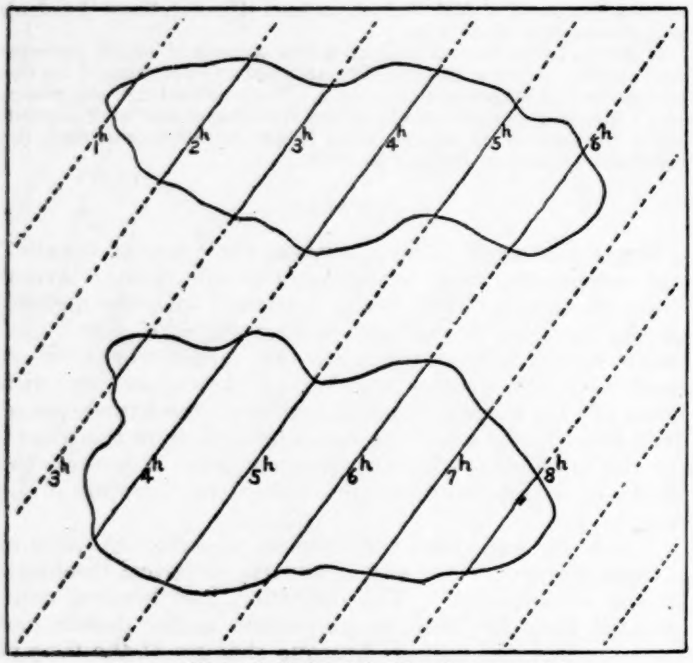


FIG. 1.—Alignment of isobronts in "thunderstorm spots."

velocity of about 60 kilometers per hour. This is what I denominated the "squall-zone" (*ruban de grain*), giving the designation of "squall-line" (*ligne de grain*) to the front border of this space.[1]

Thus, as might have been foreseen, the "zone" provoked the thunderstorm at all the points that were properly prepared, and these were very numerous over all the northeast of France and in some parts of Germany.

Two small "thunderstorm spots" (*taches orageuses*) appeared in the south of France toward 8 p. m.; finally a last thunderstorm occurred about 9 p. m. over Berlin itself, precisely at the moment when the "squall-zone" reached that city. The "squall-zone" then continued its course eastward and arrived over St. Petersburg the next day (August 28) at 5 p. m.

Thus the question was solved; the "squall-zone," which carries with it over the places that it passes, all the phenomena of the squall, has an independent existence. It may come from a distance, it may move for more than 30 hours across the whole of Europe, and it is *at the instant* of its passage that the thunderstorm most frequently bursts in places where the local conditions (previous existence of very large cumuli) are favorable.

We say "most frequently" in order not to ignore "heat thunderstorms" (*orages de chaleur*) which occur spontaneously and without wind; for these latter, it is only necessary that a calm, humid atmosphere and a hot sun favor the formation of very high cumulus summits, serving as electric excitants between the region of cirrus, charged with positive electricity, and the surface of the earth, charged with negative electricity.

Having subsequently charted the isobars for every two hours, or, when the data permitted for every hour of the day in question, I obtained proof that the isobars, which everywhere else are nearly circular, form a zigzag. Abercromby had already observed the eastern and intermediate branches (V-shaped isobars) as of this zigzag as well as the "trough" which is identically my "squall-line." When I write a volume on squalls, I shall render my homage and all the priority that belongs to him, to one of the greatest meteorologists of the last century, and to the greatest of my predecessors in the study of the question of squalls.

Another result obtained from the examination of the same charts with isobars drawn for millimeter-intervals, was the proof that the "squall-zone"—in spite of some irregularities—*corresponds exactly to a radius of the low* of which it forms a part.

TORNADOES.

These preliminaries being borne in mind, we now arrive at the question of tornadoes. In my second memoir entitled "Les grains et les tornades",[2] I showed that tornadoes *always* originate on the front edge of the "squall-zone."

Nothing, therefore, would be easier, when a very violent "squall-zone" advances from the west toward the east of the United States, than to warn by telegraph the central bureau at Washington which, after receiving a dozen such telegrams, could chart on a map the hours of the passage of the squall over such and such places, would know the trend of the "squall-zone," and the velocity and direction of its propagation parallel to itself. The bureau would thus be informed, *at least several hours in advance*, of the times at which the "squall-zone" would pass each of the points situated more to the east. Further telegrams would, however, be necessary in order to foresee the case where the "zone" might have changed its form and its velocity of translation; but these two factors are generally almost constant and change very slowly.

In each city a warning signal, a "squall cone," similar to the "storm cones" at ports, would indicate very nearly the hour of the arrival of the "squall-zone." Being advised of the passage of a very violent squall about that time (it would often be possible to tell the time within approximately 15 minutes) and that this severe squall might—like all violent squalls—be accompanied by a tornado at one or more unknown points *on its front edge*, the inhabitants would take precautions against the wind of a *certain* storm and a *possible* tornado. As soon, however, as the front edge had passed, the danger of a tornado would be over, and the people would have to guard against the wind only.

It is sometimes said that tornadoes are generated at any time in the interior of a "thunderstorm belt" (*bande d'orage*), thus confounding the thunderstorm with

[1] *See:* Les grains et les orages, Annales du Bureau central météorologique de France. 1892.
See also: Squalls and Thunderstorms, Monthly Weather Review, June, 1909, v. 37, p. 237.

[2] Annales du Bureau central météorologique de France, 1894.

the squall which is its occasional cause. But one must not conclude from this that the tornado may generate in any region of the "squall-zone." This error has arisen from the rare cases of several "squall-zones" following each other at short distances and separated by brief intervals of relative calm and inverse rotation of the wind. We have said that when the "squall-zone" has, for example, a north-south direction and the center of the depression is to the north of the observer, the wind to the right and left of the "squall-zone" is weak and southwesterly, while it is between west and northwest and violent within the "zone."

It would therefore be necessary for the central bureau to be informed whether the "squall-zone" passing over the western part of the United States, is simple or whether it is composed of several closely associated "squall-zones" [see Monthly Weather Review, v. 37, p. 239]; in the latter case, the cone for "*certain* squall with *possible* tornado" should not cease to announce the danger of a tornado until after the passage of the last of the parallel zones. When this has passed all danger of a tornado would be over until the arrival of a new "squall-zone."

This very simple method of prediction that we recommended 17 years ago—if not for tornadoes, which are very rare in our climates, at least for violent squalls—has not yet been adopted in France. It seems, however, as if it soon would be, in view of the present very marked movement in favor of agricultural forecasts. But we should be very happy if the application of the *law of squalls and tornadoes* were to be made in a country which tornadoes seem to have selected as the land of their predilection. The consequences of squalls and tornadoes can not be entirely averted, far from it, but if the people were warned of the danger, much damage could be prevented and, above all, by seeking places of safety many lives would be saved. There are, it appears, at present in America shelters erected against tornadoes; but they would be much more useful if people were informed of the *exact* hour and of the *very short* duration of the danger.

EVAPORATION FROM SNOW AND ERRORS OF RAIN GAGE WHEN USED TO CATCH SNOWFALL.

R. E. HORTON, M. Am. Soc. C. E.

[Dated Albany, N. Y., Jan. 28, 1914.]

The sketch (Fig. 1) shows the condition of the galvanized rain gage can at the end of the storm of December 26, 1913, at Albany, N. Y. Gage located at elevation about 220 above tide. At this point the entire storm fell as snow, the first portion being very damp. The first fall down town at about tide level occurred as rain. It was apparently this first snow which stuck to the outside of the gage, as shown in the sketch. This barrier on the edge of the can undoubtedly greatly increased the deflection of the later snow so that only 0.43 inch water equivalent entered the gage, although the total snowfall on the ground was 1.41 inches. There was not enough wind to cause any drifting of this snow for eight days, and there was practically no melting of the snow during this time, as the temperature was constantly very low. What melting occurred was apparently confined to about one-eighth to one-fourth inch at the surface, but was not sufficiently intense to form a solid crust. The cold weather changed the crystal form and the snow became very hard and resembled coarse granulated sugar after the first two or three days. The settlement of the snow mass is shown in the table and also the amount of loss by direct evaporation. In the first determination of the amount of snowfall samples were taken at several different locations in a yard about 35 by 100 feet. These were found to agree closely, although the depth of snow varied about 1 inch. Samples used to determine the evaporation were all taken within an area of 1 square yard. To get these samples the galvanized gage can was thrust down over the cylinder of snow, a thin-edged shovel was slipped under the edge of the can, and care was taken to get all of the snow from the ground surface.

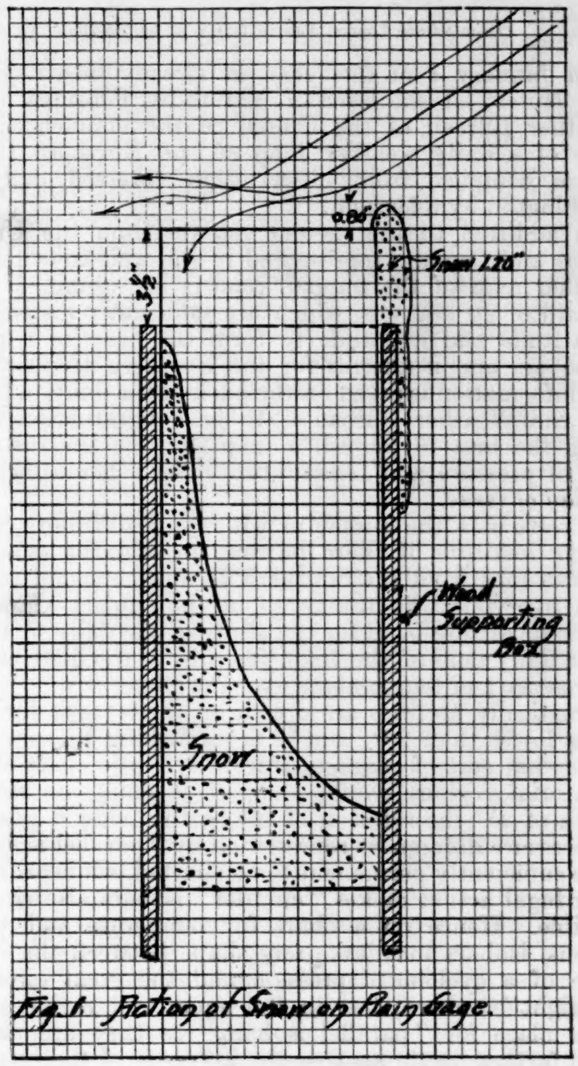


FIG. 1.—Action of snow on rain gage.

Depth, water equivalent, and evaporation loss from snow, Albany, N. Y., Dec. 26, 1913, to Jan. 4, 1914.[1]

Date.	Number of tests.	Depth on ground.	Water equivalent. Inches.	Water equivalent. Ratio.	Total loss.	Loss per day.	Maximum temperature.[2]	Mean wind movement.[2]
		Inches.			*Inches.*	*Inches.*	° *F.*	*Mis./hr.*
Dec. 26, 1913	4	11.25	1.41	0.125	0	0	22	14.6
Dec. 27, 1913		10.00					19	9.3
Dec. 28, 1913		9.50					18	3.0
Dec. 29, 1913		9.00					23	3.0
Dec. 30, 1913		8.00					37	6.8
Dec. 31, 1913		7.50					32	6.3
Jan. 1, 1914	2	7.00	1.22	0.174	0.18	0.028	19	7.5
Jan. 2, 1914	2	7.12	1.24	0.174			21	3.8
Jan. 3, 1914		6.50					36	6.2
Jan. 4, 1914	4	6.00	1.16	0.193	0.25	0.028	39	12.6

[1] Tests made about 4 p. m. each day.
[2] At United States Weather Bureau. Data contributed by George T. Todd, Local Forecaestr.

This was not difficult, as the ground was dry when the snowfall began, and there was no crust or ice layer at the bottom of the layer of snow.

The measurements of evaporation indicate an average monthly evaporation of about 1 inch per month for fairly cold weather without heavy winds, with air usually clear.

DAILY SYNOPTIC CHARTS OF THE NORTHERN HEMISPHERE AND ABSOLUTE UNITS.

[From Nature, London, Feb. 26, 1914, v. 92, pp. 715–716.]

On January 1 of this year, as already mentioned in the "Notes" of the issue of Nature for February 5, the Weather Bureau of the United States commenced the issue of a daily weather map of the Northern Hemisphere, compiled from observations received daily at Washington by telegraph.

In addition to the regular reports from the United States and Canada, represented in the well-known daily weather map of the bureau, reports are obtained from upward of 40 stations, which are sufficiently distributed in latitude and longitude to form the basis of a chart of isobars and isotherms for the Northern Hemisphere. The information is given on the back of the daily bulletin, and the Weather Bureau is to be congratulated upon being the first to publish a map showing the distribution of pressure and temperature over a hemisphere *on the day of issue.*

It rests with the bureau or with some still more enterprising institute, if there be one, to add the available observations from the Southern Hemisphere and realize what everyone who thinks about the subject knows to be the most sure basis for the study of the daily weather, viz, a daily map of the main features of the distribution of pressure and temperature over the globe.

Practically no lines are drawn on these maps for latitudes lower than 25°, and it is interesting to speculate as to what sort of characteristics a synoptic chart of the equatorial regions would show if it could be drawn. North of 25° the rotation of the earth makes it possible for pressure differences represented by "parallel isobars" to be sufficiently permanent to be charted, while ordinary centrifugal action makes "circular" isobars also equally possible. Hence on a chart for temperate and polar regions, isobars may take any shape between the small circle of a cyclonic depression and the great circle of "straight" isobars; but in the equatorial region there is no place for "parallel isobars," as they are understood farther north, because the influence of the rotation of the earth is too feeble; the winds required to balance isobars such as those to which we are accustomed would be prodigious. Consequently a pressure distribution sufficiently permanent to be mapped could only be made up of "circular" isobars, and therefore a chart of isobars for part of the equatorial region ought to be a collection of small circles with whatever may be necessary to represent the diurnal variation. It would be interesting to have this conclusion verified, and the transition between the region of circular isobars and the region of straight isobars carefully explored.

Variations of pressure, small in magnitude, but associated with weather changes, are shown as irregularities in the course of the well-known diurnal variation on barograms for equatorial regions and the translation of a collection of barograms into synoptic charts is an attractive problem. It would presumably tell us what the meteorological conditions would be if the earth were fixed and the sun went round it in 24 hours, as the ancients used to suppose.

One of the striking features of the maps now issued by the Weather Bureau is that for the first time in the history of official meteorological institutions C. G. S. units of pressure and the absolute scale of temperature are used for a daily issue of charts. The isobars are figured for every 5 millibars and the isotherms for every 10° or 5° on the centigrade scale measured from 273° below the freezing point of water.

This is indeed a remarkable step toward the unification of the methods of expressing pressure over the globe, and it has been immediately followed by the Meteorological Office in the corresponding charts which are published in the weekly weather report. The Office figures the centibars while the Bureau figures the millibars, but that is only a matter of decimal point.

Millibars are in future to be used, though not exclusively, for the international publication of the results of the investigation of the upper air, so that while it now seems likely that before many years are passed we may see a daily synchronous chart for the globe and really begin to study weather as it ought to be studied, we may at the same time expect to take leave of the inch and the millimeter as measures of pressure. They certainly have had a very long innings on a side to which they did not properly belong, and it will be interesting to see how the more scientific measure of pressure in in pressure units will adapt itself to practical requirements. The Meteorological Office is to make use of C. G. S. units of pressure for the Daily Weather Report on May 1 of the current year, and the preparations for that event have already placed some well-known facts in a curious light. The task which during the last 60 years we have been setting to British instrument makers is as follows: "Construct a barometer which will give a true pressure reading when the whole instrument is in latitude 45°, the mercury at 273° A., and its brass case at 290° A." Continental makers have had a problem that sounds simpler, viz, to construct a barometer which will give a true pressure reading when the instrument and its case are in latitude 45° at 273° A. The figures show that if instrument makers were to make a barometer which was correct at the equator at the freezing point of water, it would be correct in latitude 45° at the ordinary air temperature of 289° A. (61° F.) and at the poles at 305° A (89.6° F.). So for each latitude there would be a temperature within the common range for which the readings were true pressures. At other temperatures of course a correction would be required.—W. N. S[HAW].

THE JAPAN CURRENT AND THE CLIMATE OF CALIFORNIA.

The Editor receives so many inquiries in regard to the Japan Current and the Gulf Stream that the readers of the REVIEW will doubtless be interested in the following extracts from a well-considered article by William G. Reed, Ph. D., of the University of California, published in the Sierra Educational News, November, 1913, and the Journal of Geography, March, 1914:

The supposed relation between the climate of California and the Japan Current appears in the newspapers from time to time. In some way, not clearly stated, this current is held to have a profound effect upon the climate of the State. The Japan Current is an ocean stream of considerable interest and importance, but it is not a great factor in the climatic conditions of California. * * *

The Japan Current is, properly, that part of the drift which is warmer than the surrounding ocean; it is a warm current. As such it has its

beginning in the Pacific Ocean southeast of Japan, where the drift turns from a westerly to a northerly course, and flows to the north and then to the northeast to the Gulf of Alaska, where it divides into two branches, one continuing as a warm current through the Aleutian Islands and the other turning to the south to become the somewhat indefinite California Current. The California Current flows southward at some little distance from the western coast of the United States, and the water which has left the Tropics as the Japan Current is replaced by the California Current, so that the tropical ocean may not be losing water continually to the Alaskan region without adequate return to keep the amount of water in each place constant.

Near the coast of California the water is decidedly colder than it is in the open ocean, but as this coast strip has a lower temperature in the vicinity of Cape Mendocino than it has either north or south of this point, the cold strip must be the result of an upwelling of cold water from the depths of the ocean and not the result of an ocean current. The reports of vessels show that the movement of the surface of the ocean near the shore is irregular, but that farther out there is a general movement toward the Equator.

The facts of observation show that the Japan Current does not come within 900 miles of any part of California, and consequently can have little influence upon the climate of the State. But it is a fact that the climate of California is much milder than that of the greater part of the United States. The explanation is to be found in the great ocean which lies to the west and in the fact that the winds prevailingly blow from this ocean to the land. The temperature of the ocean water varies little from 55° during the year; in some places it is more and in some places less, but it is everywhere relatively constant through the year. The air lying over this great body of water has nearly the same temperature as the water, but were it not for the westerly winds, the climate of California would be little influenced by the ocean.

Compared with the land areas in the same latitudes the oceans have very mild climates. Everywhere the oceans are warm in winter and cool in summer because water is, of all the substances we know, among the most difficult to heat and to cool. The result is that the temperatures of the ocean and the air over the ocean remain nearly constant. But land is about twice as easy to heat and twice as easy to cool as is water, so that the land and the air over it have warm summers and cold winters, warm days and cool nights.

The fact that the winds blow from the ocean to the land is of the greatest importance to California. It is these winds which bring the mild ocean air over the land and give to this State a climate cooler in summer and warmer in winter than that of other parts of the country. The Pacific Ocean and the westerly winds from the ocean can and do produce all the beneficial results that have been claimed for the Japan Current, and it is to these two features of nature that we owe our mild climate. Whatever effect the Japan Current may have upon the Gulf of Alaska and upon the climate of the Territory of Alaska, and there is no doubt that this effect is very important, the State of California owes nothing to this warm current. The cool summers in the coast region of the State and the fogs which occur during that season are, in part, due to the presence of the cold water off the coast, and that part of the North Pacific drift known as the California Current may be one of the reasons for the existence of this cold water, although a far more important reason seems to be the upwelling of the cold water from the ocean depths. It is the Pacific Ocean and the westerly winds to which we must look for the chief reasons why the climate of the Golden State is favored above that of other lands.

MILD WINTER OF 1913–14.

AN UNUSUAL PHENOMENON.

Dr. Louis Bell writes from Boston, U. S. A., to describe an unusual meteorological phenomenon observed there last month. On January 13, which was the coldest day known in Boston for many years, the thermometer not ranging above 0° F. for a period of 30 hours extending through the entire day, Dr. Bell, upon entering a large train shed some 75 feet high and of a very extensive area, found that snow was steadily falling, produced by the congelation of the steam from the numerous locomotives. The interesting point was that the snow had aggregated into flakes of fair size, not distinctly crystalline, but still flakes, in spite of the short distance of the possible fall. The thermometer was then about 5° F. below zero, and in the evening at a similar temperature the whole interior of the train shed was still white with this deposit of snow. The general phenomenon, of course, has been many times recorded, but is very rarely seen, particularly on so large a scale and for so long a time.

WINTER OF 1913–14.

The exceptionally mild character of the present winter is being maintained until its close, and for a persistent continuance of warm days in January and February it surpasses all previous records. At Greenwich the thermometer in the screen was above 50° for 18 consecutive days from January 20 to February 15. Previous records since 1841 have no longer period than 11 days, in the months of January and February combined, with the thermometer continuously above 50°, and there are only four such periods—1846, January 21–31; 1849, January 16–26; 1856, February 6–16; and 1873, January 4–14. Besides these there are only three years, 1850, 1869, and 1877, with a consecutive period of 10 days in January and February with the temperature above 50°. The persistent continuance of the absence of frost is also very nearly a record. To February 24 there have been 30 consecutive days at Greenwich without frost in the screen, and the only years with a longer continuous period in January and February are 1867, with 37 days; 1872, with 43 days; and 1884, with 32 days. The maximum temperatures in the two months have seldom been surpassed. In many respects there is a resemblance between the weather this winter and that in 1899, when in February blizzards and snowstorms were severe on the other [American] side of the Atlantic, with tremendous windstorms in the open ocean, whilst on this side of the Atlantic the weather was exceptionally mild. It is to be hoped that this year we shall be spared the somewhat sharp frosts experienced in the spring of 1899. (Nature, London, Feb. 26, 1914, v. 92, p. 720–721.)

ON THE AMOUNT OF EVAPORATION.[1]

By Y. HORIGUTI.

[Dated Kobe Meteorological Observatory, January, 1913.]

(1) In the present note I intend to give some results of my investigation of the evaporation of water in an atmometer that is freely exposed to wind and sunshine.

This apparatus is a cylindrical copper vessel 20 centimeters in diameter and 10 centimeters deep. It is placed on the surface of ground that is covered with sod. Fresh water is poured in it to the depth of 2 centimeters and is freely exposed to sunshine and wind.

Every morning at 10 o'clock the amount of evaporation is determined by measuring the loss of water during the exposure. When rain or snow has fallen during the exposure the measured evaporation is corrected for the amount of precipitation shown by the rain gage placed near and at the same height with the atmometer.

First let us investigate theoretically the relation of evaporation and other meteorological elements.

(2) Suppose the case when the vaporizing water is not exposed to wind and direct sunshine, and is unhindered. Moreover, let us assume that the cylindrical vessel is so large that the effect of the surface tension at its periphery may be neglected.

Let the z-axis be vertical. Let p be the partial vapor pressure, then the upward force is $\frac{\partial p}{\partial z}$. The gravity and the resistance of air act downward.

[1] Revised reprint from Journal of the Met. Soc. of Japan, May, 1913, 32d year, No. 5, pp. 14–26.

Let ρ be the density of the water vapor at the partial pressure p and the absolute temperature T, but ρ' the density of the air at the partial pressure p' and the absolute temperature T.

Let u be the upward velocity of diffusion of aqueous vapor. Then the resistance is proportional to $\rho\,\rho'\,u$.

Then the equation of motion is

$$\rho\frac{d^2z}{dt^2}=\frac{\partial p}{\partial z}+a\,\rho\,\rho' u \quad (1)$$

where t is time and a is a constant. The mechanism of evaporation is not known, but we assume that there is a layer of saturated vapor on the exposed surface of the water, and the vapor passes into the air by diffusion [without convection currents]. Therefore the process of evaporation may be treated as the diffusion of a gas through other gases. In such a case the acceleration of vapor may be neglected, and

$$\frac{\partial p}{\partial z}+a\,\rho\,\rho' u=0 \quad (2)$$

Now $\rho u\times 1$ sq. cm. = the amount evaporated from a unit area in a unit time.

Put m = the evaporated mass of water in a unit time from a unit area, then

$$\rho u=m \quad (3)$$

Let δ' be the density of the air at the normal pressure P_0 and the normal temperature T_0, then

$$\rho\,\rho'\,u=\frac{\delta' T_0\,p'}{TP_0}m, \quad (4)$$

Therefore equation (2) becomes

$$\frac{\partial p}{\partial z}+a\frac{\delta' T_0\,p'}{TP_0}m=0, \quad (5)$$

since $p'=P-p$, where P is the total pressure, therefore

$$\frac{\partial p}{\partial z}=a\frac{\delta' T_0}{TP_0}(P-p)\;m=0. \quad (5')$$

For simplicity, suppose that P and T are constant between $z=0$ and $z=h$; that the partial pressure of water vapor at $z=0$ is p_1, or the maximum vapor pressure at the temperature T, and that at $z=h$ it is p_2.

Put

$$a\frac{\delta' T_0}{TP_0}=\frac{1}{k} \quad (6)$$

then

$$k\frac{\partial p}{\partial z}+(P-p)\;m=0 \quad (7)$$

or

$$m=-k\cdot\frac{1}{P-p}\cdot\frac{\partial p}{\partial z} \quad (7')$$

Integrating we get

$$m\int_0^h dz=-k\int_{p_1}^{p_2}\frac{1}{P-p}\cdot dp$$

$$mh=k\log\left(\frac{P-p_2}{P-p_1}\right) \quad (8)$$

$$m=\frac{k}{h}\log\left(1+\frac{p_1-p_2}{P-p_1}\right) \quad (8')$$

Now since p_1 and p_2 are small quantities compared with P_1, the above expression may be expanded, and we may neglect the terms of the second and the higher orders.

Therefore we have

$$m\doteq\frac{k}{h}\cdot\frac{p_1-p_2}{P} \quad (9)$$

Let w be the density of the water, dH be the depression of the water level in unit time.

Then wdH is the mass of the evaporated water in unit time from unit area, therefore

$$wdH\doteq\frac{1}{h}\cdot\frac{p_0 T}{a\delta' T_0 P}(p_1-p_2).$$

Hence we obtain

$$dH=\alpha(p_1-p_2) \quad (10)$$

where

$$\alpha=\frac{1}{h}\cdot\frac{TP_0}{a\delta' T_0 P}\cdot\frac{1}{w}.$$

From this we see that, as is well known, the [daily] amount of evaporation [or rate] is proportional to the deficiency of saturation.

(3) The discussion of the last paragraph refers to an ideal case; in an actual case it is necessary to take 24 hours for the time unit. Even the greatest amount of evaporation during 24 hours at Taihoku is less than 10 mm. on the average of the five years of observation (1900–1904).

The temperature, the total pressure, and the partial pressure are not constant as we assumed in the last paragraph, but are functions of the time.

The evaporation gage is a circular cylinder 20 centimeters in diameter instead of being of infinite dimension as was assumed in the ideal case; therefore in the actual case the boundary conditions and the effect of the meniscus must be taken into consideration.

Moreover, the evaporating surface is exposed to wind and sunshine. It is also very difficult to estimate the amount of evaporation in a rainy day, and in fact I often experienced so-called "negative evaporation."

Therefore the amount of evaporation observed by this method does not attain an accuracy of the order of 0.01 millimeter. Dr. Okada discussed the accuracy of evaporation observations in the Bulletin of the Central Meteorological Observatory (Tokyo), No. 1. His report indicates that from 2 to 61 years' observations are necessary to reduce the probable error of mean result of evaporation observations to 0.1 millimeter.

The foregoing considerations make it obvious that formula (10) does not hold in the practical case; therefore I devised the following empirical formula:

$$M=a+b(p_1-p_2)$$

where M means the amount [per day or the rate] of evaporation expressed in millimeters of depression of the water level, and a and b are constants.

I shall proceed to find the values of a and b. I assume the total pressure P and the absolute temperature T to be constant through the year, because the fluctuation in a year does not have any considerable influence on the total amount of evaporation. The probable error of observed total is greater than the effect of this fluctuation.

(4) The constant b depends only on the deficiency of saturation. The terms p_1-p_2 and a depend on all the remaining factors, viz, the effect of the inequality between the water temperature and the air temperature,

the effect of wind, sunshine, boundary conditions, etc. Therefore a is not a constant, but varies from month to month.

[Tables I to VIII omitted.]

TABLES IX AND X.—*Computed values of b.*

Station.	Latitude.	Longitude.	b
Taihoku	N. 25° 02′	E. 121° 31′	1.01
Naha	N. 26° 13′	E. 127° 41′	1.06
Nagasaki	N. 32° 44′	E. 129° 52′	0.89
Hamada	N. 34° 53′	E. 132° 05′	1.10
Tu	N. 34° 43′	E. 136° 31′	1.03
Tokyo	N. 35° 41′	E. 139° 45′	0.94
Hakodate	N. 41° 46′	E. 140° 44′	1.47
Sapporo	N. 43° 04′	E. 141° 21′	1.43

The constant b at the first six stations of Table IX–X are nearly equal, though these stations are far distant from each other, and the amounts of evaporation there observed are also very different. The general uniformity of b is natural, as I pointed out above, because b depends only on the deficiency of saturation.

But at Hakodate and Sapporo b differs from its value at the other stations. This is probably owing to the differences in the condition of evaporation. A glance at Tables VII and VIII [omitted], shows that the mean temperature in December, January, February, and March falls below the freezing point, and that even in other months the water in the atmometer will often freeze in such cold localities. Of course the values of b in the case of the vaporization of ice must be different from those for water. In fact the value of b for Hokkaido, which has a severe winter, is greater than that for the other stations having milder climate; the ratio is nearly as 1 to 1.4.

As already stated the constant a depends on the boundary conditions, wind velocity, etc.; but it seems that this constant depends chiefly on the temperature of the water, which my former calculation assumed to be equal to the air temperature. But in summer, daylight is much longer than nighttime, therefore the mean temperature of a water surface must be far higher than that of the surrounding air. The deficiency of saturation calculated by means of the air temperature and the vapor pressure is therefore a little smaller than the actual value. Hence a correction, arising from the difference in temperature of the air and the water in the atmometer, must be applied to the value of a calculated with the air temperature. Then a will vary from month to month and will show some relations to the duration of daylight.

The following table contains the computed monthly values of a, assuming b as a local constant without seasonal variations:

TABLE XI.—*Monthly values of constant a.*

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.
Taihoku	0.42	0.73	0.77	0.88	0.62	0.93
Naha	−1.02	−0.49	0.17	0.29	0.27	0.85
Nagasaki	−1.39	−0.21	0.33	0.11	0.04	−0.85
Hamada	−0.83	−0.36	−0.16	−0.09	−0.36	−0.06
Tu	0.36	0.46	0.78	0.98	0.80	0.48
Tokyo	−0.07	0.03	0.30	0.28	0.17	−0.06

Station.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Taihoku	0.58	0.50	0.49	0.58	0.28	0.41
Naha	0.25	−0.05	−0.48	−0.79	−0.56	−0.71
Nagasaki	0.26	−0.58	−0.94	−1.36	−0.56	−0.51
Hamada	−0.31	−0.46	−0.74	−1.16	−1.05	−1.05
Tu	0.76	0.18	0.53	−0.12	−0.27	−0.15
Tokyo	0.24	0.04	−0.42	−0.57	−0.37	−0.26

I analyzed the constant a by the method of harmonic analysis, and Table XII contains the values of the constants in the Fourier series:

TABLE XII.—*Constants in harmonic series; analysis of a.*

Station.	a_0	a_1	a_2	a_3	ϕ_1		ϕ_2		ϕ	
					°	′	°	′	°	′
Taihoku	0.60	0.14	0.05	0.07	351	50	111	48	254	4
Naha	−0.19	0.73	0.10	0.18	282	42	135	0	180	
Nagasaki	−0.39	0.51	0.13	0.25	17	1	0	0	148	14
Hamada	−0.55	0.44	0.22	0.12	288	26	341	34	180	
Tu	0.39	0.49	0.17	0.09	307	34	287	21	40	42
Tokyo	0.06	0.35	0.11	0.14	318	17	354	17	128	40

Here α is the amplitude, and ϕ is the phase angle. The amplitudes of the first term are greater than the amplitudes of the higher terms.

At Taihoku α_1 is less than α_0; at the other stations α_1 is greater than α_0 and the amplitudes of the higher terms. Its maximum values occur between March and June, and its minimum value between October and January. It seems to me that this fact may be accounted for by considering the duration of daylight.

The wind velocity must affect in some degree the rate of evaporation, but when we consider the mean monthly evaporation the wind effect is not conspicuous. I tried many times to find the relation between the wind velocity and the constant α, but the effort resulted in a failure.

(5) The above theoretical formula must represent the evaporation in shade, as in a thermometer screen, better than that at a place freely exposed to sunshine and precipitation. But the effect of the shelter on the rate of evaporation must be considered as one of the limiting conditions in the theoretical investigation. In general the air circulation through the shelter is not sufficiently free. Therefore the vapor pressure in the screen is not equal to that of the outside, especially when the atmometer is placed in it. Generally the vapor pressure inside the screen will be greater than that outside. Then the deficiency of saturation will depend on the velocity of the air circulation, and the velocity of the air circulation in the screen will be a function, $F(w)$, of the wind velocity. Hence the deficiency of saturation is a function of wind velocity. Therefore it is necessary to substitute $F(w)(p_1 - p_2)$ for $\alpha(p_1 - p_2)$ in formula (10).

In my computation I have used the results of observations made at the Hamada Meteorological Observatory, published in the Journal of Meteorological Society, Tokyo, August, 1911.

Now we shall find the functional form of $F(w)$. For a first approximation it seems to be sufficient to put it as the linear function of wind velocity. But the parabolic formula is more appropriate. We give below these two formulæ:

$$\text{(A)} \quad M = (p_1 - p_2)w$$

$$\text{(B)} \quad M = (p_1 - p_2)\{0.20\sqrt{w - 3.4} + 0.27\}$$

where w is the wind velocity in meters per second.

When the wind velocity is less than 3.4 meters per second, the effect of the wind velocity on the amount of evaporation is not significant, and formula (B) becomes—

$$M = 0.27(p_1 - p_2).$$

The effect of wind velocity becomes more and more conspicuous as the velocity increases.

We give in Table XIV the differences between the calculated and observed values of the evaporation by these two formulæ.

In the means for the period 1904–1908, the calculated and observed values coincide pretty well.

(6) In his "Lehrbuch der Meteorologie" Prof. J. von Hann gives the following formula of the velocity of evaporation:

Dalton's formula

$$\frac{dv}{dz}=A(E-e),$$

where v is the amount of evaporation from water surface; z, time; E, maximum vapor pressure; e, actual vapor pressure; A, a constant.

Weilenmann and Stelling put the evaporation rate proportional to the wind velocity. On the other hand, De Heen, Shierbeck and Svenson assumed that the evaporation is proportional to the square root of the wind velocity. Moreover, they introduced $T:T_0$, or $(1+\alpha t)$, into their evaporation formula.

Trabert puts

$$v=c(1+\alpha t)(E-e)\sqrt{W},$$

where W is the wind velocity; c, the constant depending upon atmospheric pressure. When the mean pressure is B and the current pressure b, then c becomes

$$c\times\frac{b}{B}.$$

Dalton's formula is identical with that which I have deduced theoretically in this note. For formula (10) is

$$dH=\alpha(p_1-p_2).$$

But formula (10) and Dalton's formula do not represent the observed values.

TABLE XIV.—*Differences between the observed evaporation, M, and the values calculated by formulæ (A) and (B).*

	Jan.	Feb.	Mar.	Apr.	May.	June.
1904.						
M	1.33	1.52	1.41	1.47	1.73	2.00
By (A)	−0.09	0.13	0.15	0.30	0.38	0.26
By (B)	0.03	0.14	0.11	0.26	0.29	0.15
1905.						
M	1.22	1.42	1.08	1.44	2.36	0.85
By (A)	−0.03	−0.12	0.04	0.10	0.03	−0.11
By (B)	−0.03	−0.06	0.00	0.05	−0.01	−0.12
1906.						
M	1.30	1.21	1.62	1.96	1.43	1.14
By (A)	−0.23	−0.12	0.13	−0.19	0.26	0.17
By (B)	−0.12	−0.03	0.20	0.16	0.23	0.23
1907.						
M	1.37	1.16	1.40	1.76	3.04	1.74
By (A)	0.00	−0.10	0.21	0.25	−0.72	−0.04
By (B)	0.03	−0.06	0.21	0.19	−0.29	−0.16
1908.						
M	1.48	1.21	1.51	1.43	2.13	1.69
By (A)	−0.06	0.01	−0.03	0.24	0.09	−0.09
By (B)	0.00	−0.01	0.03	0.19	0.01	0.21
Mean.						
M	1.34	1.30	1.40	1.61	2.14	1.48
By (A)	−0.08	−0.04	0.10	0.17	0.01	0.04
By (B)	−0.02	0.00	0.11	0.17	0.05	−0.02

TABLE XIV.—*Differences between the observed evaporation, M, and the values calculated by formulæ (A) and (B)*—Continued.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.						
M	1.83	2.45	1.66	1.40	2.25	1.97
By (A)	−0.21	−0.21	−0.19	0.08	−0.04	−0.33
By (B)	−0.35	−0.39	−0.30	0.02	0.03	−0.09
1905.						
M	1.81	1.31	2.13	1.70	1.92	1.47
By (A)	−0.24	−0.12	0.23	0.05	0.02	0.00
By (B)	−0.39	−0.27	0.10	−0.06	0.12	0.05
1906.						
M	1.33	1.57	1.19	1.52	1.54	1.77
By (A)	0.23	0.05	−0.12	−0.12	−0.20	−0.47
By (B)	0.46	0.14	−0.18	−0.18	−0.24	−0.16
1907.						
M	1.55	1.92	1.14	1.73	1.45	1.98
By (A)	−0.01	−0.02	0.17	0.44	0.12	−0.43
By (B)	0.05	0.03	−0.26	0.48	0.03	−0.15
1908.						
M	1.51	1.88	2.05	1.59	2.41	1.87
By (A)	0.25	0.04	−0.27	−0.07	−0.20	−0.09
By (B)	0.32	0.05	−0.36	−0.18	0.31	−0.12
Mean.						
M	1.61	1.83	1.63	1.59	1.91	1.81
By (A)	0.00	−0.06	−0.04	0.08	−0.06	−0.26
By (B)	0.00	−0.09	−0.20	0.02	−0.05	−0.09

Weilenmann and Stelling assume that M varies as W, and De Heen, Shierbeck and Svenson that M varies as $\sqrt{W}$. Their formulæ give us almost the same results in my calculations. My parabolic and linear formulæ hold good equally.

Therefore it may be concluded that evaporation in the shade may be fairly well represented by the formulæ of either Weilenmann, Stelling, De Heen, Shierbeck, Svenson, Trabert, or myself. But the evaporation in open air can not be represented by those formulæ.

It seems to me that there remains an ample field for further research.

EDITOR'S NOTE.—Various papers bearing on evaporation by Ferrel, Russell, Marvin, and others will be found in the MONTHLY WEATHER REVIEW and other publications of the United States Weather Bureau. An elaborate Annotated Bibliography of Evaporation, by G. J. Livingston, appeared in the MONTHLY WEATHER REVIEW from June, 1908, to June, 1909, and also reprinted.

A valuable summary of our knowledge of the laws of evaporation, for the period 1840 to 1892, will appear in the MONTHLY WEATHER REVIEW for March, 1914.

PREVENTION OF FOG.

By pouring oil on the disturbed ocean surface ship captains have often been able to greatly diminish the damage that would have otherwise resulted during severe storms. M. Georges Onofrio, director of the Fulviére Observatory, at Lyon, France, suggests that by pouring oil upon inland rivers and lakes we may check the evaporation and therefore the formation of fog. Experiments have been made on this subject by allowing a mass of tow moistened with a small quantity of oil to dip into a running stream of water. Thus an oily coating scarcely a millionth of an inch in thickness, spreads over the inland waters. If successful the 62 days of local fog should be replaced by 62 days of good weather annually. A mineral oil is the cheapest but animal and vegetable oils have some advantages. It is estimated that the total expense for the region that furnishes objectionable fogs in the neighborhood of Lyon will amount to about $30 a day.

Too much must not be expected from this proposed use of oil since many regions in the United States owe the occurrence of fog, not so much to the evaporation from water surfaces and cultivated land surfaces and forest surfaces, but principally to the cooling of the lower atmosphere which has derived its moisture from great distances. The cooling that produces the fog is due to radiation from the lower atmosphere upward through clear air into space beyond.

Such cooling will produce fog even in regions that are quite dry, providing the atmosphere has brought a little moisture thither from a distance. In the case under consideration at Lyon, cold dry winds from the north and east allow of low temperatures near the ground and dry air just above it. In such a case as Pittsburgh we have evaporation from warm river water at the base of a deep ravine, clear cool air above the ravine. In the case of San Francisco we have relatively cold water pushed up along the coast and clear cold air above it. In all these cases the hydrographic and atmospheric conditions are far more important than the evaporation from local rivers.—[C. A.]

DO CLOUDS YIELD SNOW EASIER THAN RAIN?

Mr. Douglas F. Manning, of Alexandria Bay, N. Y., under date of January 11, 1914, propounds the above question and adds:

After many years of observation it has seemed apparent to me that they do; in other words, a cloud will precipitate snow, which under the same conditions, but dew-point above freezing, no rain would result. This seems to apply to the lower clouds, especially those of the strato-cumulus type which are seen with the westerly and northerly winds during winter a little while after the passage of a "low." These clouds are generally very shallow and in long rolls (such appearance helped, no doubt, by perspective) but from such clouds copious flurries of feathery snow fall. This same type of cloud occurs in the summer time but of much larger growth without causing the least suggestion of rain.

At the beginning of a well-developed cold wave a peculiar form of cloud accompanies the west and northwest winds, having all the appearance of an alto-stratus formed at the strato-cumulus level, and which produces the same optical effect as the alto-stratus, namely, a bright patch of light in the vicinity of the sun or moon but no halo. In fact, perhaps this is an alto-stratus at a low level owing to extreme cold. From this cloud a fine powdery snow falls, which is so fine that it sifts through any crevice or crack in windows and doors. Such clouds, although of much greater altitude and thickness in summer, do not even yield a drizzle. Lastly, there is a form of high alto-cumulus that is most common during periods of calm cold weather, especially when an area of low barometer is forming far to the southwest. This cloud is of a very flimsy nature, so much so that the sun or moon can be seen shining feebly, although perhaps surrounded by a corona, from which the air is filled with a feathery snow of most beautiful formation but which is so fine a texture that one wonders what becomes of it all. This cloud appears in the summertime in large fleecy battalions but no shower will fall.

It seems to me that the process of snow building is such that a large feathery snowflake can grow from a given amount of water vapor and reach the earth with but little loss from evaporation, whereas, under the same conditions but higher temperature, it would be impossible for raindrops of sufficient size to form or ever reach the ground.

There is a strange form of snow which occasionally falls and so far I have never read any explanation of it. I do not mean the frozen drops of rain, termed sleet, of which the pellet is clear ice; but of a compact pellet of snow about the size of a pea and which generally falls during squally weather, especially in March and April up here, but I have seen it in other States.

I am highly interested in the weather and once planned to take the observers' examination, but circumstances would not permit, so content myself with a homemade observatory where I spend spare hours after my day's work in a printing office. * * *

Having watched the clouds for years, it always mystified me why the cirrus should take such totally different forms from those of the lower levels. I contented myself with the idea that their being composed of ice dust produced this effect, but such an idea was dispelled in March, 1912, when I observed several fogs during severe, calm, cold days with the temperature 20° below zero (−20° F.), in which such fog particles were composed of ice spiculae and produced the same optical effect as cirrus and cirro-stratus, namely, a large halo around the sun, which in this case could only be a few feet from the observer. These fogs occurred in the early morning during periods of anticyclonic weather and were very local; when viewed from a distance they had no different appearance from those fogs that are formed in the spring and fall under similar conditions; so it seemed very apparent that the frozen condition could not be called upon to explain the varied formations of cirrus clouds, although, of course, the conditions of temperature and especially pressure are widely different between the frozen fog and the cirrus cloud. * * * This phenomenon is quite common in this part and nearly always occurs with rising barometer and light or diminishing north winds, the cloud sheet moving slowly from the same [northerly] direction. Under such conditions the sky is clear far to the north, as if it were, so to speak, the boundary line between the high and low, for clear weather soon follows, with lower temperature. I am very positive that no rain could ever fall from such muslin-like clouds. * * * I will keep careful watch of the clouds, direction, etc., if such would be of any use.

During the past few days (Jan. 10–17, 1914), if you will examine the weather maps, you will see that severe cold has been prevailing in northern New York, while to the south and west much higher temperatures were prevailing with west and southwest winds. This warm current of air must have risen over the cold air which lay as a blanket over us, for it rained with the temperature between 18° and 22° F. on the 16th, but, of course, froze on the trees, covering them with ice.

NOTES.

Professor Hergesell, head of the Meteorological Institute of Strassburg, has been appointed director of the Aeronautical Observatory at Lindenberg, in succession to Professor Assmann.

Prof. A. A. Ivanov has been appointed director of the University Observatory at St. Petersburg.

Provision is to be made in connection with the French department of war for continuing the aerological work carried on by the late M. Léon Teisserenc de Bort, at his observatory at Trappes.

On account of the interest widely manifested by meteorologists in the relations between climate and agriculture, as well as between climate and forestry, we take pleasure in repeating the invitation to membership extended by the secretary of the American Forestry Association at Washington. The association endeavors to extend its influence as to forest conservation and development by increasing its membership.

We regret to notice the death of Prof. F. Pockels, of the University of Heidelberg, on August 29, 1913, at the age of 60 years. Prof. Pockels was deeply interested in the application of mathematical analysis to natural phenomena; his paper on the rainfall from air ascending a mountain side was published in the Monthly Weather Review for 1901, pages 152–159 and 306–307, and is almost the only attempt to explain the distribution of rain falling from a layer of air steadily ascending or descending.

A correspondent urges the introduction of a new thermometer scale, whose fiducial, or fixed points, shall be the freezing point of water as the zero point and the internal heat of the human body as 100°. It would

scarcely be necessary for us the mention this reversion to the practice of three centuries ago, were it not for several errors quoted by the inventor as being matters of common belief.

(1) The freezing point of water is not a fixed point any more than is the boiling point of water; each of them depends on the pressure at the surface of the water, and accurate thermometric scales are so graduated that they refer primarily to certain standard pressures.

(2) The temperature of the human body is not a standard and fixed condition, even in a state of health; it varies among nations throughout the world and is not even a "practically invariable point in health."

(3) The proper scale for the student of the atmosphere is the international centigrade scale of absolute temperatures, whereon the freezing point of water at standard pressure is 273° and its boiling point is 373°.

We regret to learn of the death, which took place on Tuesday, January 27, of Mr. R. T. Omond, the meteorologist. He was appointed first superintendent of the Ben Nevis Observatory in 1883, and held the post till 1895, when failing health compelled him to resign. From 1903 he was honorary secretary of the Scottish Meteorological Society, and was joint editor of the Ben Nevis Observatory publications, completed three years ago. He was a luminous writer, and, though he suffered from an incurable illness, his output was such as would have done credit to a man in full health, while his effective support of the Scottish National Antarctic Expedition showed the keenness and energy with which he was able to throw himself into practical matters.—(Atheneum, London, Feb. 7, 1914.)

As the British Association meets in Australia this year there will be no meeting in England in 1914. It is proposed to hold in Edinburgh, in September, *a conference of observers and students of meteorology* and allied subjects. One of the objects of the conference is to bring together observers in meteorology, climatology, oceanography, limnology, atmospheric electricity, terrestrial magnetism, and seismology, as well as persons who are interested in the discussion of the observations. Special attention is to be directed to the teaching of meteorology in schools and to the relations of meteorology to aviation.

The Italian Meteorological Society is arranging to hold an international congress at Venice in September, 1914. There will be five sections, viz, climatology, agricultural meteorology, aerology, marine meteorology and pure meteorology.

Under date of January 2, 1914, ex-Director H. E. Hamberg, of the Swedish Statens Meteorologiska Centralanstalt, writes that he resigns his position as director of that bureau on January 6, 1914, and that Prof. Dr. Nils Ekholm, the acting director, has been appointed as director of the bureau.

Prof. Ekholm writes that he is reorganizing the Swedish Weather Service with a view to establishing a system of twice-daily (a. m. and p. m.) observations and telegraphic reports for the benefit of the storm-warning service. We may therefore expect to receive, before long, a series of Swedish weather maps comparable with the tri-daily Danish "Vejrberetning." It is to be hoped that these new Swedish maps will embrace a sufficient number of Norse and mountain stations to make them representative of the conditions over the whole of Scandinavia.

Prof. Ekholm also states that he plans to extend the scope of the publications of the Central Meteorological Bureau. These now embrace but an annual report, with an occasional supplementary volume of special compilations.

The graduate School of Agriculture, under the auspices of the Association of American Agricultural Colleges and Experiment Stations, will hold its sixth session June 29 to July 24, 1914, in the College of Agriculture, Columbia, Mo. Correspondence as to membership and courses of instruction should be addressed to A. J. Meyer, Registrar, College of Agriculture, Columbia, Mo.

The general secretary of the Société Astronomique de France announces the loss of its former vice president, E. Durand-Gréville, who died suddenly January 20, 1914, in his seventy-sixth year. The secretary of the society promises to publish his very latest notes.

His death is a loss particularly felt by students of thunderstorms, squalls, etc.

He wrote numerous papers on the "albe" or second twilight; the theory of hail and of the thunderstorm; mammato clouds; the laws of squalls.

SECTION III.—FORECASTS.

FEBRUARY WEATHER.

By ALFRED J. HENRY, Professor of Meteorology.

PRESSURE IN NORTHERN HEMISPHERE.

The Aleutian low.—The normal change in atmospheric pressure from January to February in the region of the Aleutian Islands, as determined from the noon Greenwich International Observations, 1878-1887, is about (plus) 0.15 inch. The actual change January to February was a very small amount in the opposite direction. Pressure was relatively high in February during the first week of the month, and almost continuously low thereafter. A marked depression occupied the region from the 12th to the 18th, and again from the 20th to the 27th.

Pressure at Honolulu.—During February the pressure at Honolulu was relatively low during the first half of the month, and persistently high during the second half. The character of the variations at Honolulu were only very roughly opposite in phase to those of the Aleutian low.

Iceland.—The normal change in barometric pressure January to February is almost negligible. The actual change was negative and amounted to about 0.35 inch. There were but two periods during the month when pressure reached the normal value, viz, on the 6th, and again on the 16th-17th. On both occasions pressure was high over the Azores; that is, above the seasonal normal. While the character of the oscillations at both points were similar in phase, it so happens that the same increase in pressure at both places does not necessarily produce the same resultant pressures with respect to the normal, owing to the great difference in the absolute values of the initial pressures.

The fluctuations at the Azores were generally small and unimportant; positive and negative oscillations followed each other at comparatively short intervals.

Siberia.—The pressure fluctuations in central Siberia, as at Irkutsk, were likewise small and unimportant, thus indicating a month of changeable weather, not, however, departing very widely from normal conditions.

FEBRUARY PRESSURES IN THE UNITED STATES, WITH SOME REMARKS ON CYCLONES AND ANTICYCLONES AS UNITS OF WEATHER CONTROL.

Monthly mean pressure signifies merely the arithmetical mean of the pressure values recorded during the month—in this case, the arithmetical mean of twice daily observations at 8 a. m. and 8 p. m. seventy-fifth meridian time. A much better idea of the actual fluctuations of pressure is secured by plotting them in the form of a curve, the peaks of which will indicate the passage of areas of high pressure (anticyclones) and the valleys the passage of areas of low pressure (cyclones).

The use of the anticyclone and the cyclone as units of weather control, as advocated by Prof. R. DeC. Ward, of Harvard, would seem to have some distinctive advantages in discussing the weather of the month as produced by the eastward movement of these phenomena.

The attempt will be useful in possibly establishing more definitely than is at present known the relation which subsists between the movement of highs and lows, and the resulting weather for a considerable time over large areas. Should it ever become possible to forecast the run of highs and lows for a month or a season it will be an easy matter to supply in advance the details of the weather in various parts of the country for the same time.

As a first step in the proposed discussion it is convenient to utilize the charts published in the Monthly Weather Review, showing the tracks of highs and lows; but first of all we must disentangle the apparently hopeless network of tracks that are found on the charts named. This can be done by classifying the highs or lows according to their respective places of origin, and drawing a separate chart for each class; thus we will be able to perceive the variation both in number and direction of both highs and lows, and to arrive at a more rational understanding of at least the visible processes whereby one season is warmer or colder, wetter or drier, than another.

We have divided both the highs and the lows into five classes, according to the geographic position of their apparent origin, and have prepared 55 charts (not reproduced here), 5 for each month, for highs and lows, respectively.

February lows, 1904-1914.

The classes adopted for lows are: (1) Pacific (coast of Washington, Oregon, and California only); (2) Alberta; (3) East Slope, embracing eastern Colorado, Kansas, Oklahoma, northern New Mexico, and the Panhandle of Texas; (4) Southern Slope, embracing southern Nevada, Arizona, southern New Mexico, and southwestern Texas; and (5) the west Gulf. The latter includes the immediate Gulf coast west of the mouth of the Mississippi and extreme southern Texas to the mouth of the Rio Grande River.

Any division according to geographic boundaries must be more or less artificial, since there is, roughly speaking, but a single place of origin of winter storms that visit the United States, viz, the Pacific Ocean. We distinguish, however, between lows that pass into the United States directly from the Pacific and those which come in from the Pacific by way of the Canadian Northwest; and since the great majority of the latter come in by way of Alberta, we have given the name "Alberta" to those storms which first appear in the Canadian Northwest Provinces. We make a further distinction between Alberta and Pacific storms; the former seem to have a much greater tendency than the latter to break up into separate and apparently detached storms, and occasionally to disappear as separate and distinct storms only to apparently reappear a few hundred miles to the southeast or south as a fresh disturbance. On the other hand,

lows that enter the United States along the coast of southern California, or move to that region from a more northern point of entrance, seem to possess, for February at least, more cohesion, more vigor, and thus, as a rule, they pass across the continent with little, if any, loss of their original energy. These vigorous Pacific storms, however, form only a relatively small per cent of the total number of lows that originate over the Pacific and pass inland. A count of such storms for the last eleven Februarys discloses the fact that only 50 per cent of them finally reach the Atlantic.

The so-called East Slope and South Slope and West Gulf lows, in the belief of the writer, owe their origin either to the eastward movement of an Alberta low or a North Pacific low in higher latitudes, or to the development of a whirl in the rear of a rapidly moving area of high pressure over the Gulf States or Tennessee. In other words, they are mostly secondary developments.

TABLE 1.—*February lows during 1904–1914, classed according to origin.*

Year.	Alberta.	Pacific.	East Slope.	South Slope.	West Gulf.	Total.
1904	4	5	2	1	1	13
1905	4	3	1	1	3	12
1906	3	4	3	0	0	10
1907	3	2	2	0	0	7
1908	3	4	0	2	0	9
1909	5	4	0	2	0	11
1910	1	4	4	1	1	11
1911	2	4	1	2	1	10
1912	2	0	1	3	1	7
1913	3	1	1	2	2	9
1914	6	1	4	2	1	14
Mean	3.3	2.9	1.7	1.4	0.8	10.0

The figures of Tables 1 and 2 in connection with the charts, show at once that while one February is much like another in the larger features which control the weather, there is a considerable variation in the smaller features, and particularly in the combinations of the different types which after all give individuality to the month. Some additional remarks will now be made in further elucidation of this point, before discussing the weather of February, 1914.

Table 1 shows quite clearly that the majority of February lows belong to the Pacific and Alberta types. The course taken by storms of these types after they have passed inland is east to the St. Lawrence Valley with more or less looping to the south. The extreme southerly point reached is, of course, the Gulf of Mexico; the course thence being generally northeast to the St. Lawrence Valley or New England. Both types of storms, however, may vary decidedly from the course above set forth, as in the case of February, 1904, when the Pacific type of storms almost invariably moved southeastward over the Rocky Mountain region and the southern Plains States to the Gulf of Mexico. Arriving there several of them expired, while those which persisted took an easterly course over Florida instead of moving to the northeast, as is usual. Moreover, lows of the Alberta type for this month moved almost directly east over the Great Lakes, with practically no looping to the south, and there was no movement of lows from the Gulf region northeastward.

Space does not admit of giving the result of this distribution except to say that precipitation, while abundant in the Gulf States, was elsewhere deficient. The temperature was relatively high southwest of a line drawn from Florida to British Columbia, and low to the northeast of that line, the greatest depression being in the lake region. Another abnormality of the month was the singular fact that the Pacific lows that moved southeast over the Plains States were not followed by Alberta highs; consequently cold northerly winds, so frequent in like pressure distributions, were absent. Possibly the absence of Alberta highs may be attributed to the local temperature distribution over Alberta and other northwestern provinces. On this point the director of the meteorological service of Canada says:

> The mean temperature of February [1904] was decidedly below average throughout the Dominion and to the greatest extent in Alberta, where the negative departure amounted to 17° F.

The principal abnormalities of February, 1905, were exceptionally low mean temperatures in practically all districts east of the Rocky Mountains, the depression of temperature amounting, in the lower Mississippi Valley and northern Texas to 10° F per day; deficient precipitation except on the Pacific Coast and over Arizona and New Mexico; and great excess of sunshine over the upper Missouri Valley. The explanation of these abnormalities is somewhat involved, since it concerns not only the storm tracks but a combination of high pressure and low pressure over the central Rocky Mountain Region in such relation to each other as to produce a generous distribution of cold northerly winds over practically all districts east of and including the Plains States.

This configuration for which the name "Rocky Mountain" type is suggested, consists essentially of a strong area of high pressure or anticyclone central over the upper Missouri Valley, with its crest generally over Montana, in which maximum pressure ranges from 30.70 to 31 inches, in combination with an area of low pressure which is situated on the other side of the mountains, approximately 500 or 600 miles southwest of the crest of the anticyclone. The pressure differences over the strip of country intervening are generally more than an inch of mercury and the differences in temperature may be as much as 80° F. The fact that these great extremes are separated by the Rocky Mountains doubtless tends to greatly augment the contrasts, especially in those districts, as in Colorado, where the mountain barrier is a considerable one, and the transit from the plains to the mountains is quite abrupt.

The winds throughout the region of apparent strong pressure gradients are without exception gentle in force, and mostly from a northerly or easterly quadrant. The barometric gradient is probably fictitious, due entirely to temperature differences on the two sides of the mountains, since the winds do not respond in the slightest degree to the apparent pressure gradients.

Observations of temperature during the prevalence of the Rocky Mountain type show that the plains temperatures are quite low, generally close to zero or below, Fahrenheit, while the air temperature increases with altitude on the eastern slope of the mountains, finally differing but little at the higher altitudes from the air temperatures on the western side of the mountain at lower levels, which, it may be remembered, are under cyclonic control, and range from the freezing point to a few degrees above.

The anticyclonic member of the combination which is central over the upper Missouri Valley, seems to possess the ability of remaining in statu quo for 24 to 36 hours, meanwhile sending off forks, or branches, which move directly to the east or southeast. These branches soon become separate anticyclones and continue their movement to the Gulf of Mexico or the Atlantic. As

soon as the anticyclone begins to fork, or separate, that region along which the separation takes place, or the fault is produced, to borrow a geological term, becomes favorable ground for the development of an area of low pressure of the trough form, with opposing winds, rain on one side, and snow or sleet on the other. We have, then, a typical winter storm, with a retreating high, or anticyclone, on the east side, and a semipermanent anticyclone on the northwest, which, immediately the cyclone reaches the Mississippi Valley, sends off a second anticyclone in its rear. In this manner the country is successively swept by cold northerly or northwesterly winds, and the temperature is very materially lowered. There are other modifications of the Rocky Mountain type of which space does not admit description.

Passing now to a consideration of the abnormalities of the weather of February, 1905, as the result of cyclonic and anticyclonic control, we would say that the Rocky Mountain type of weather prevailed without a break from the 1st to the 7th and again, with short interruptions, from the 9th to the 15th.

The extraordinary rains in Arizona and New Mexico were caused by the meanderings of a low (No. I–A of Chart II, Monthly Weather Review, v. 33, Feb., 1905) which for seven consecutive days oscillated back and forth from the Pacific to the Rocky Mountains, and finally breaking through the barrier of high pressure over the Missouri Valley passed eastward to the Atlantic. This low at the same time served as the far, or west side, member of the Rocky Mountain type before referred to.

The low monthly mean temperature east of the Rocky Mountains is explained as due to the fact that the weather was under the control of the Rocky Mountain type from the 1st to the 7th, and again from the 9th to the 13th. In that time, and up to the 19th, six anticyclones passed from the upper Missouri Valley to the Atlantic, and their movement was so timed as to produce and sustain low temperature everywhere east of the Rocky Mountains, as before stated.

The excess of sunshine in the upper Missouri Valley was due to the prevalence of strong anticyclones over that region during the first half of the month.

In February, 1906, no lows developed over the West Gulf or the south slope. Precipitation was deficient in nearly all districts. The temperature was near the normal in the southeastern part of the country, and considerably above the normal west of the Mississippi. No lows developing in either the west Gulf or south slope apparently had a tendency to prevent the southward movement of highs into those regions.

February, 1907, with only seven lows, was dry in all parts of the country, with relatively low temperatures in the east and high temperatures in the west. The shortage in rain we attribute directly to the small number of lows that were developed; also to the fact that all of the Alberta lows followed the northern circuit, viz, across the Great Lakes, and that no important lows passed from south to north over the interior valleys.

February, 1908, with a larger number of lows, mostly in the middle and northern regions of the United States, brought fairly abundant rains in the majority of districts, with cold in the Atlantic and Pacific districts and higher temperatures in the Rocky Mountains and Plains States. The characteristic feature of this month was a fairly uniform distribution of lows both in the lake region and the interior valleys.

February, 1909, was the warmest month of the series, and had also fairly abundant precipitation, especially east of the Mississippi and south of the Ohio. The immunity from cold is not fully understood. The month had eleven lows and but seven highs. The latter were generally lacking in cold and of short duration, especially in the Alberta region. Any weakness in the movement or intensity of highs in the Alberta region seems to be reflected elsewhere in the United States. Alberta lows, although they followed the northern circuit, generally looped farther southward than usual. Had each low been followed by a corresponding high the temperature would undoubtedly have been much lower. Mean temperature in the southern portion of Canada was also above the normal, but in a lesser degree than in the United States; while in the northern portions of Canadian provinces temperature was below the normal, and this was especially pronounced in Alberta, where in the south the positive departure was 2° F., while in the north the negative departure was from 5° to 7° F. We recognize, although we are unable to explain the fact, that in some years cold is intense and anticyclones numerous over Alberta, while in other years temperatures are relatively high and anticyclones infrequent.

Only the very broad departures from normal conditions are susceptible of what seems to be a rational explanation.

Following are some of the most obvious relations between the movements of lows in the United States and the resultant weather:

(1) When the tracks of lows are massed along the northern circuit temperature will be high and precipitation light east of the Rocky Mountains. The winds will be mostly southerly, and therefore relatively warm. The opportunity for precipitation comes with dynamic cooling or cooling by mixture, both of which are absent in marked degree under the pressure conditions above outlined.

(2) A uniform distribution of lows in latitude, and especially a movement from southwest to northeast over the interior valleys, are essential to heavy rains east of the Mississippi. (*b*) The development of high pressure over the northeastern Rocky Mountain Slope and the Upper Missouri Valley and also of low pressure over the southwestern slope of the Rocky Mountains is essential to fairly abundant precipitation in the Missouri Valley, the Plains States, and the Central Rocky Mountain Region. (*c*) An absence of high pressure over the northern portion of the Great Basin and frequent lows advancing from the Pacific are the essentials of a season of abundant rains on the Pacific Coast. The reasons for the above are obvious.

(3) Low temperature east of the Rocky Mountains seems to be conditioned on the magnitude of the high-pressure area that must cover British North America and the course in latitude of the lows which traverse the United States, a movement in low latitudes being favorable to great cold and in high latitudes to unusual warmth.

AREAS OF HIGH PRESSURE DURING 1904–1914.

The writer has classed the highs of February, 1904–1914, according to their origin, as described in this paper for lows, except that the places of origin for highs is somewhat different from that chosen for lows. The highs appear to originate mainly in Alberta and to the eastward of that province, centering for the western part of Canada in Alberta and for the eastern portion in the region of Hudson Bay. Highs also skirt the Pacific coast, coming from the south and passing inland over Washington and Oregon, and either merge with Alberta highs or pass to the south and east and lodge over the Great Basin region.

In forming Table 2, the regions selected were as follows: (1) Pacific; (2) Alberta; (3) Ontario, east of the one-hundredth meridian; (4) eastern slope of the Rocky Mountains; and (5) east of the Mississippi.

TABLE 2.—*February highs classed according to origin during 1904–1914.*

Year.	Pacific.	Alberta.	Ontario.	East Slope.	East Mississippi.	Total.
1904	1	7	0	4	1	13
1905	1	2	2	1	1	7
1906	2	6	2	0	....	10
1907	2	3	0	0	....	5
1908	2	3	3	2	....	10
1909	0	2	1	3	1	7
1910	0	5	1	1	....	7
1911	3	2	1	0	....	6
1912	3	4	2	0	....	9
1913	2	4	3	0	....	9
1914	5	4	2	....	....	11
Mean	2.0	3.8	1.5	1.0	0	8.5

We remark that the total of 94 highs charted in February, 1904–1914, is 19 less than the total number of lows for the same period. In some years the difference is greater, as in the warm February of 1909, when 11 lows were charted and only 7 highs. In February, 1905, 12 lows and but 7 highs were charted.

The principal place of origin of the highs is in the Canadian Northwest, probably over the mountain region that parallels the coast northward from British Columbia. It seems probable that offshoots from the more or less permanent area of winter high pressure that must occupy that region are the cause of low temperatures in the United States. A knowledge of the development of that area of high pressure during the winter months would aid in the forecast work of the United States Weather Bureau.

In the absence of observations beyond the meteorological frontier of the weather map, which is outlined by the stations of Calgary and Edmonton, in Alberta, and Prince Albert in Saskatchewan, we can only draw inferences as to the actual pressure conditions over northern British Columbia, Alberta, and Saskatchewan, the terra incognita of the weather map.

The pressure changes along the frontier—that is, the changes from rising to falling pressure, and vice versa—are very rapid; it is not as if the cycle of change from rising to falling pressure, or vice versa, occupied a period of, say, 36 hours, as in the case generally elsewhere within the region of observation, but the cycle seems at times to exhaust itself within 12 hours, as is evidenced by the change in phase frequently manifest in the twice daily observations. By change in phase is meant a change from rising to falling pressure from one observation to the next.

In the United States the areas of high pressure which occasionally lodge over the Great Basin and the western Rocky Mountain regions seldom, or never, pass eastward across the main chain, but offshoots are discharged to the southeast over Oklahoma and northwestern Texas. It may be that in a similar way the winter area of high pressure over British North America discharges masses of chilled air from its southeastern front simultaneously from Edmonton and Calgary, in the west, to Prince Albert, in the east, and that the air movement is thus directly southward, rather than southeastward. The only instance of a movement from the northeast occurred on the 22d, when high area No. VIII, Chart II, seemed to advance or spread to the southwest, the crest of the high advancing from Winnipeg at 8 a. m. of the 22d to Devil's Lake, on the evening of that date, thus giving an apparent movement of the high toward the southwest.

The large number of Alberta highs, the facility and rapidity with which they overspread the northern boundary States, and the intense cold that accompanied the most of them, are collectively the feature of the weather of February, 1914.

THE WEATHER OF FEBRUARY, 1914.

The only portion of the country not traversed by one or more lows was the extreme southwest, including southern California. It is true that a low was central off the Oregon and Washington coast, from the 17th to the 22d, and that its presence caused strong southeast winds, and rain over the Pacific coast States, with snow in the mountains of Arizona, Nevada, California, Oregon, Washington, Utah, and Idaho. This low, however, failed to move inland as a vigorous storm and apparently filled up on the 22d over the State of Washington. The majority of the lows of the month belonged to the Alberta type—a type, be it remembered, that is characterized by an uncertainty of movement and development over the central Rocky Mountain Region that is the bête noire of the forecaster.

On the p. m. of the 21st a low appeared over the central Rocky Mountain region, which later developed into a storm of much strength; it was one of those Alberta lows which pave the way for high northerly winds and low temperatures to sweep southward from the Dakotas to Texas. There were two such storms during the month, both attended by cold weather and freezing temperatures to the Gulf coast. Elsewhere east of the Rocky Mountains the weather was changeable, short periods of fair weather being followed by rain in southern and snow in northern districts. The month as a whole failed of being a wet one because of the erratic movement of at least three lows; Nos. III, VII, and XI of Chart No. III; low No. III apparently filled up over Virginia during the 5th; low No. VII advanced as far as northeastern Tennessee by the p. m. of the 13th, when it diminished greatly in strength. In the meantime a secondary storm center developed off the North Carolina coast, and moved northeastward as a severe storm, especially off the southern New England coast, on the morning of the 14th.

It seems to be a fair precept in forecasting that when a low is diminishing in energy the probability is that a fresh center will shortly develop, generally a little to the east and south of the dying low.

The most severe storm of the month along the Atlantic Coast developed as a secondary storm during the afternoon of the 28th—see Chart III, No. XIII–A. This development occurred in connection with the rapid eastward movement of low No. XIII during the 27th–28th. Pressure in this low was 29.16 inches at Winnipeg at 8 p. m. of the 27th. Twelve hours hence the center was at Alpena, and pressure had risen to 29.44. In the meantime a shallow depression was passing eastward over the Gulf of Mexico, with pressure near 30 inches, off the mouth of the Mississippi. Twelve o'clock specials on the 28th showed a fall in the barometer along the Gulf Coast, but nothing alarming. At 5 p. m. a special observation from Macon, Ga., showed a very rapid fall in pressure. Storm warnings were thereupon hoisted from Norfolk to Savannah. Three hours later, when the 8 p. m. observations had been received, a storm of marked intensity was central off Savannah, Ga., whereupon warnings of northeast gales

were extended from Norfolk to Eastport. The subsequent history of this storm will form a part of the March Review.

From the point of view of the forecaster the failure of southern lows to advance into northeastern districts was one of the features of the month, notably in connection with lows Nos. III, VI-A, VII, and IX, which seemed to be marked for the southern New England Coast but moved off to sea over the Atlantic. These failures to move to the northeast are now believed to have been due to the obstruction presented by New England highs; and the precept to be drawn from the failures is that a low will not move into a region that will be occupied on the morrow by an incoming high. The forecaster must distinguish between a high in situ and an incoming high. The reason back of this is that with an incoming high, as in the case quoted, the winds would be from the north or northwest, with falling temperature; conditions inimical to the development and sustenance of a low.

STORM WARNINGS DURING FEBRUARY, 1914.

More than the usual number of severe storms visited the North Atlantic Coast. Warnings were issued on the 6th, 7th, 10th 13th, 14th, 16th, 20th, 23d, 25th, and 28th. On the Pacific Coast the main storm period occurred between the 17th and 22d. Warnings were issued on these dates, and also on the 23d, 26th, and 28th.

The Gulf Coast was not visited by severe storms, although warnings for high northwest winds were displayed on the 6th and 23d.

THE VALUE OF WEATHER FORECASTS IN THE PROBLEM OF PROTECTING FORESTS FROM FIRE.

By EDWARD A. BEALS, District Forecaster.

[Dated Weather Bureau, Portland, Oreg., Nov. 29, 1913.]

Climate is defined as the sum of weather conditions affecting animal and plant life, and as trees come under the head of plant life, they are affected by climate from whatever point of view the cause and effect of climate in connection with forests may be considered. The integral elements of climate are the general atmospheric conditions, or in other words the weather from day to day, and it is the purpose of this paper to show whether or not advance information about the weather can be used to advantage in reducing the fire losses in forested areas.

Weather forecasts are not accurate, nor will they ever be, no matter how perfect the method by which they are made. They are the product of the human mind, which is liable to error in every walk of life. Mistakes are sometimes made in the transmission of forecasts, and sometimes they are wrongly interpreted; while we can not expect perfection, it is safe to expect the forecasts to be verified about five times out of six, and in some special lines, such as warnings of floods and storms, the percentage of accuracy is even greater than this.

Weather forecasts are made in the expectation that those receiving them will be able to protect their interests when threatened by adverse weather, otherwise they are of no special benefit to anyone. It would do no good to warn a vessel of a coming storm if that vessel could not avoid it or was so constructed that she could not take in sail, batten down her hatches, and securely lash movable articles to the best advantage. Neither would it do any good to advise a farmer of a coming frost if he were unprepared to protect his crop. It would only be giving him cause to worry before the damage was done, and as worry is said to shorten life he should be saved from as much of it as possible.

Trees according to their species require heat and moisture in variable quantities. There is a maximum, a minimum, and an optimum of both elements for each species which varies with the season of the year. Forests are subject to serious injury if the winds are strong enough to blow down a large number of trees before they are matured. If known beforehand that a forest is threatened by damaging extremes in temperature, precipitation, or wind, no economic protective measures could be taken to avert the danger, and it would suffer according to the extent and character of the subsequent weather, however severe it might be.

Damage by extremes in temperature, precipitation, or wind is not great when compared with the damage done by fire that is fanned by winds of moderate force. Preparedness against fire can be taken in all forested areas by increasing fire patrols, putting out smouldering fires, and shutting down dangerous logging operations for a short period; therefore if winds favorable for spreading forest fires can be foretold the information would be of great benefit to all concerned in the preservation of forests.

Droughts and periods of hot weather contribute to the fire hazard, but these conditions alone do not necessarily portend the occurrence of a great fire, as without wind an incipient fire would spread slowly and could soon be extinguished by modern fire-control methods. In quiet air a fire causes inflowing currents that might attain a surface velocity of 20 miles or more if the fire was intense and not too limited in extent. These inflowing winds would operate to check spreading, except as large embers were carried aloft, and after leaving the vortex drifted slowly to a distance before coming to the ground. In such cases a new fire would be started, and if there were many such embers, and they were not promptly extinguished, the fire might burn over a large area.

Usually after a period of hot, still weather we can look for increasing winds, and if the period of hot weather has been attended by drought conditions are most threatening, and it is then that reliable wind forecasts could be used to good advantage. The problem of making them is extremely difficult, much more so than the predicting of stormy winds along our sea coast, owing almost if not wholly to the fact that the sea is level and the forests are generally located in a hilly or mountainous country. Over the sea the winds follow the pressure gradients with uniformity, while over the land, especially in mountainous countries, they are deflected by topography to such an extent that at times it is impossible to recognize their relationship to the pressure gradients, either as regards force or direction.

Winds causing the spread of forest fires may be divided into three classes in the order of their importance, as follows: Cyclonic winds, mountain and valley breezes, and winds having monsoon characteristics. All three classes may prevail at the same time, and they act and react on one another in a most confusing manner. Our largest and most destructive forest fires occur when cyclonic winds are the dominating feature over a large area, and especially when they cause foehn or chinook conditions on the leeward side of mountains. By cyclonic winds reference is made to those caused by a large atmospheric disturbance wherein the winds blow systematically, and they may be associated either with a cyclone or an anticyclone.

Winds of monsoon character prevail near the sea, and they can not be traced more than 100 or 200 miles into the interior of the United States. They are nothing more than magnified sea breezes, whereby during the height of the summer season the sea breeze has acquired such proportions that all the potentiality of the land breeze is expended in lessening the force of the sea breeze, which dominates both day and night, but with diminished velocity at night. It is for this reason they are characterized as monsoon winds instead of sea breezes.

In summer, monsoon winds prevail along the Pacific coast and at times in the Gulf States, but seldom if ever are they observed in the Atlantic States. Near the Great Lakes and along the Atlantic coast land and sea breezes modify the character of the winds for short distances inland, but ordinarily these winds are of such inferior strength as to be negligible quantities when there are forest fires within their confines.

The greatest complications are caused by mountain and valley breezes, and our geographical knowledge of them is meager. They blow up the valleys during the day and down them at night, but in some localities exceptions occur and the mountain breeze blows down the valley in the daytime. Winds of the latter character are regularly observed at the foot of glaciers on warm days, and they may become so strong as to be dangerous. These winds cease at night, and they reach their highest velocity shortly after noon. The cyclonic and monsoon winds may accelerate or retard the mountain and valley breezes, depending upon the angle in which the two forces meet.

As both monsoon winds and mountain and valley breezes are dependent upon the amount of insolation, convection, and radiation, their strength is reduced during cloudy weather, and they are modified to a greater or less extent when the atmosphere is hazy or smoky. During periods of clear and quiet weather in the open country mountain and valley winds may become violent in favorably situated canyons with wide openings, and their force and direction on all slopes is more or less controlled by the contour of the foothills and mountains.

As probably two-thirds of the nation's standing timber is in mountainous countries where mountain and valley breezes are the distinguishing features, a knowledge of their behavior is essential in forecasting the movement of the wind within a limited area, such as would be included within the boundaries of a forest fire occurring in these regions, even though it devastated several townships and of itself was considered a large fire. In other words, what to the lumberman would be a large area in consequence of the loss sustained, to the forecaster would be a small area in which to forecast exact conditions that are subject to modifications due to topography that he is familiar with only in a general way.

The weather forecaster can foretell within a reasonable degree of accuracy the general movement of the air over a large area, and it ought not to be difficult for the man on the ground, familiar with the behavior of the mountain and valley breezes in his neighborhood, to adapt such a forecast to fit local conditions. He should bear in mind that when the general forecast, which is based upon cyclonic conditions, indicates strong easterly winds that in nearly all valleys lying east and west the winds on the east side of a mountain would be accelerated during the daytime and retarded at night, and the reverse condition would prevail on the west side of the mountain. In transverse valleys modifications would ensue in direction and force, with the latter varying between the extremes occurring in the east and west valleys and the former guided by the contour of each valley. In localities where the mountain breeze blows down the valley in the daytime allowances would have to be made the opposite of those for the up-valley breezes. When other winds are forecast, local adaptations of a similar nature must be made for individual localities in order to overcome the discordances that otherwise are bound to occur.

The season for forest fires is from April to October, inclusive; they are most prevalent in September and of rare occurrence in June. In Forest Service Bulletin No. 117, on page 23, a list of historic fires is given, as follows:

TABLE 1.—*Historic forest fires in the United States and Canada.*

Date.	Name of fire.	Location.	Area burned.	Lives lost.
			Acres.	*Number.*
1825—October	Miramichi	Maine and New Brunswick	3,000,000	160
1837—(?)	Seboois	Maine	130,000	
1846—(?)	Yaquina	Oregon	450,000	
1853—May	Pontiac	Quebec	1,600,000	
1860—(?)	Nestucca	Oregon	320,000	
1868—September	Coos	do	300,000	
1868—September	St. Helen	Washington and Oregon	300,000	
1871—October	Peshtigo	Wisconsin	1,280,000	1,500
1871—October		Michigan	2,000,000	
1876—(?)	Big Horn	Wyoming	500,000	
1880—September	Bagot	Quebec	288,000	
1881—September	Michigan	Michigan	1,000,000	138
1891—May	Comstock	Wisconsin	64,000	
1894—July	Phillips	do	100,000	13
1894—September	Hinckley	Minnesota	160,000	418
1902—September	Columbia	Oregon and Washington	604,000	18
1903—April-June	Adirondack	New York	450,000	
1908—August	Fernie	British Columbia	64,000	9
1908—September	Chisholm	Minnesota	20,000	
1910—August	Great Idaho	Idaho and Montana	2,000,000	85
1910—October	Baudette	Minnesota and Ontario	300,000	42

From this list the Michigan, Hinckley, Columbia, and Great Idaho fires have been selected as a basis for study of the meteorological conditions just prior to their occurrence, to see if the character of the winds fanning the flames might not have been predicted sufficiently in advance to have been of material aid in preventing the losses that took place. Similar studies of conditions just prior to the other historic fires could be made to advantage, but the meteorological data are lacking for the earlier fires, and exact information regarding the dates and areas burned over is not at hand for those of recent date, other than those selected. The Michigan and Hinckley fires occurred in a comparatively level country, with very little, if any, complication in wind movement due to topography, while the Columbia and great Idaho fires occurred in a mountainous region where valley and mountain breezes are the rule rather than the exception.

CONDITIONS PRECEDING MICHIGAN AND HINCKLEY FIRES.

The Michigan fire caused the death of 138 people, and the property loss was estimated to be slightly over $2,000,000. The principal burnt district was in the eastern part of the State between Saginaw Bay and Lake Huron, and this and the adjoining territory constitute what is known as "The Thumb" of Michigan. It was on August 31, 1881, that the fires became alarming, but it was not until September 5 that the great conflagration started its work of destruction. It lasted three days, or until Wednesday, September 7, when heavy rains fell and quenched the flames.

The conditions leading up to the fires are described in Signal Service Bulletin No. 1, as follows:

In September [1881] no penetrating rain had fallen for almost two months. Almost every stream was dry. Many wells had become empty. The swamps had been burned to hard clay by the sun, fiercer in its heat than it had been for years before. The vegetation of the

fields and woods had become tinder. The earth was baked and cracked, the heat having penetrated to an unusual depth. Everything was ready to feed the fires when they finally came. Old roots, pine tops, branches, brush heaps, timber, and the parched earth made the fuel for the burning.

The weather maps just prior and during this fire are reproduced in figures 1, 2, 3, and 4.

The Hinckley fire was the smallest in area of the four under consideration, but the loss of life was the greatest of any but one in the history of forest fires in the United States and Canada. It occurred on Saturday, September 1, 1894, and was confined to Pine, Carlton, and Mille Lacs

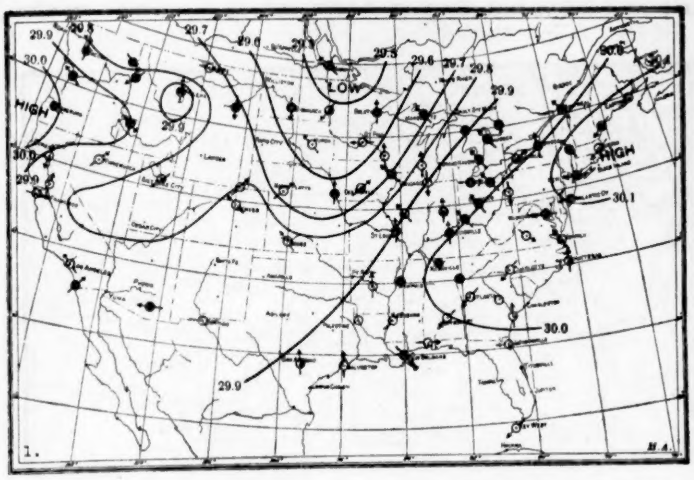


FIG. 1.—Michigan fire. Map for Sept. 4, 1881, 7 a. m., Washington time. — isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

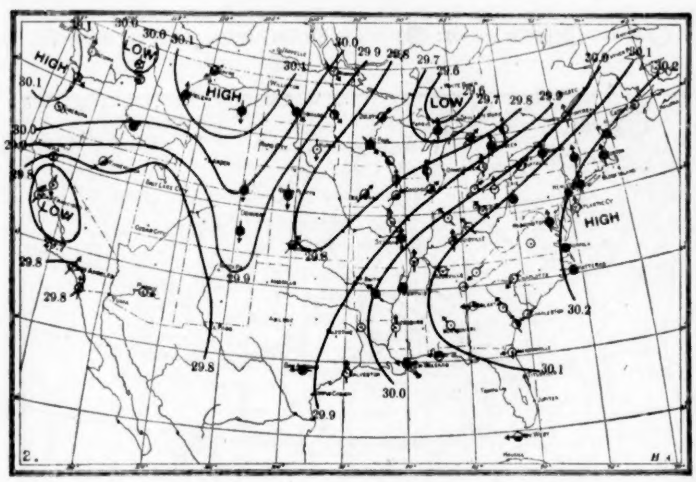


FIG. 2.—Michigan fire. Map for Sept. 5, 1881, 7 a. m., Washington time. — isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

Counties, which are situated in the eastern part of Minnesota nearly midway between St. Paul and Duluth. The Rev. William Wilkinson published in 1895 the history of this fire, and from his book the conditions leading up to it are given as follows:

> These conditions, i. e., great lack of rainfall, high temperature, dry air, and light winds, were persistent for a period of nearly four months, resulting in parched earth, crops destroyed, vegetation of all kinds dried up, and down timber and brush but tinder for the match. Fires had been started in August in various places throughout the timber regions of Minnesota, Wisconsin, and Michigan, and smouldered or sprung into life as the winds arose. Such was the conditions up to the 1st day of September, which ushered in high winds, that fanned the fires into fierce flames, themselves also creating a strong upward draft, increasing with the increase of the fierceness of the fires which caused such destruction of life and property.

The distribution of pressure causing the winds that "fanned the fires into fierce flames" is shown in figures 5 and 6.

CONDITIONS PRECEDING THE COLUMBIA FIRE.

The next historic fire occurred on the west side of the Cascade Mountains in the neighborhood of Portland, Oreg., in 1902. According to compilations by the Forest Service there were 18 lives lost in this fire, and property amounting to $12,767,100 was destroyed. The fires were worst between September 8 and September 12, the latter

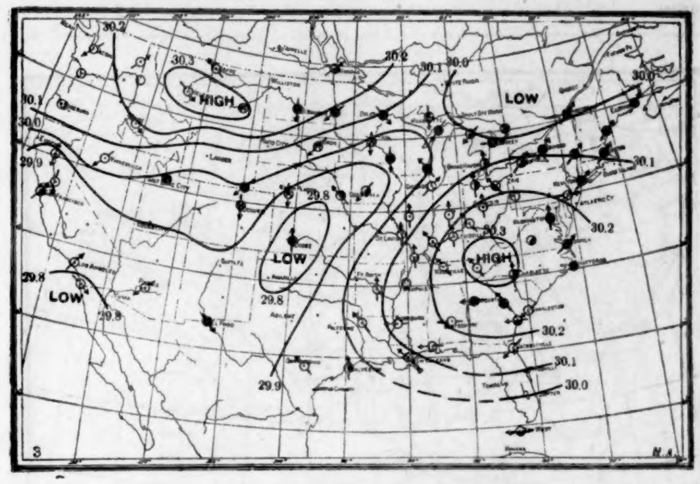


FIG. 3.—Michigan fire. Map for Sept. 6, 1881, 7 a. m., Washington time. — isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

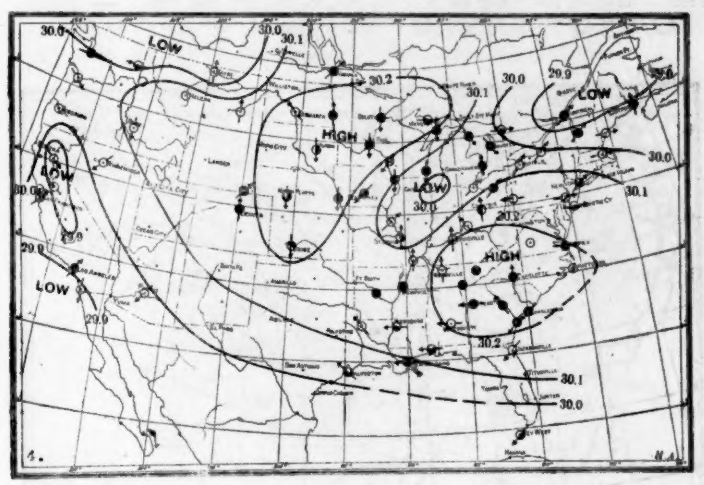


FIG. 4.—Michigan fire. Map for Sept. 7, 1881, 7 a. m., Washington time. — isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

date being known as the "dark day" in nearly all the region west of the Cascade Mountains. Previous to this time fires had been smouldering in many places in western Washington and western Oregon.

In an unpublished manuscript by Mr. William T. Cox, of the Forest Service, he describes the conditions preceding this fire as follows:

> The past season [1902] was particularly favorable to forest fires. Not only was the summer very dry but the two preceding summers were wet in May and June, thus interfering with the burning of slashings, and allowing an unusual amount of débris to accumulate. In the early part of September the wind blew from the east most of the time. An east wind after it gets west of the Cascades is ready to absorb any quantity of moisture, so the forest was soon in the condition of tinder.

The temperature and rainfall departures at Portland, Oreg., for the six months preceding the fire are shown in the following table:

Month.	Temperature.	Rainfall departures.
1902.	°F.	Inches.
March	+1.3	+0.61
April	−2.1	+ .66
May	−0.7	− .17
June	0.0	− .98
July	−1.2	+1.22
August	+0.9	− .21

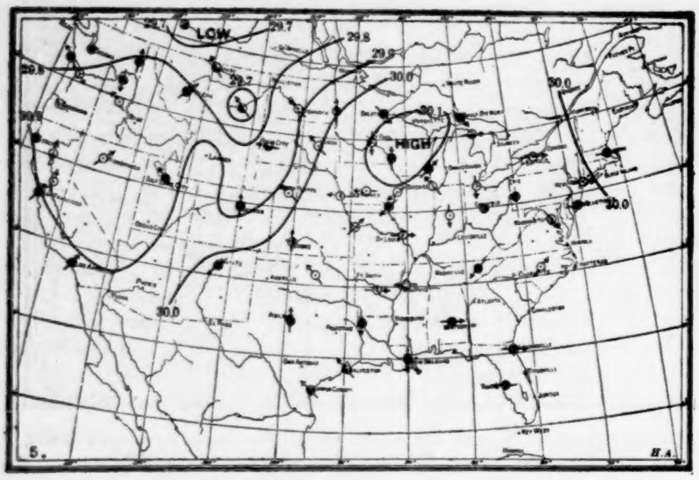


FIG. 5.—Hinckley fire. Map for Aug. 31, 1894, 8 a. m., 75th mer. time. — isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

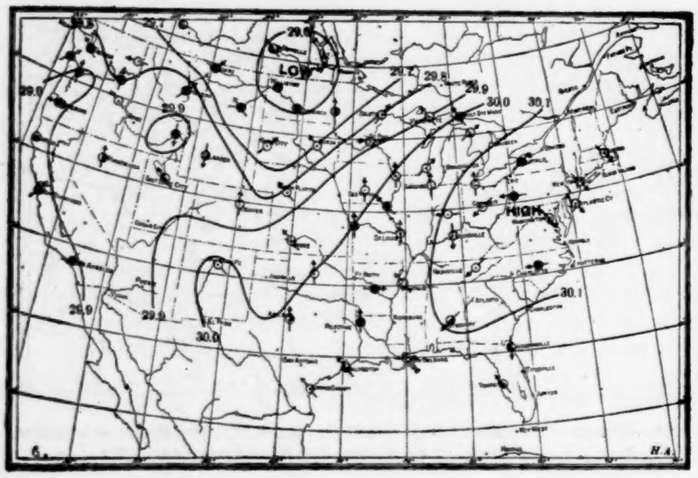


FIG. 6.—Hinckley fire. Map for Sept. 1, 1894, 8 a. m., 75th mer. time. — isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

Figures 7 to 12, inclusive, show the meteorological conditions prevailing from September 7 to 12, 1902, inclusive, which is the period just before and during the time the greatest damage was done.

THE GREAT IDAHO FIRE OF 1910.

The worst season for forest fires in recent years was in 1910, which is credited with two of historic character in Forest Service Bulletin No. 117. One of these occurred in August, and is known as the Great Idaho Fire, and the other in October, and is called the Baudette Fire. The former burned over about 2,000,000 acres in Idaho and Montana and the latter swept through 300,000 acres of timberland in Minnesota and Ontario. Of the 127 persons who perished in these two fires, 85 lost their lives in Idaho and Montana and 42 in Minnesota and Ontario.

For reasons previously given the Baudette fire is not considered in this article, but there is sufficient information at hand about the Great Idaho Fire to analyze the conditions that prevailed at that time. The fires in 1910 were most destructive in the Cœur d'Alene and St. Joe Valleys in Kootenai, Cœur d'Alene, and Shoshone Counties in Idaho, but they were numerous elsewhere in the

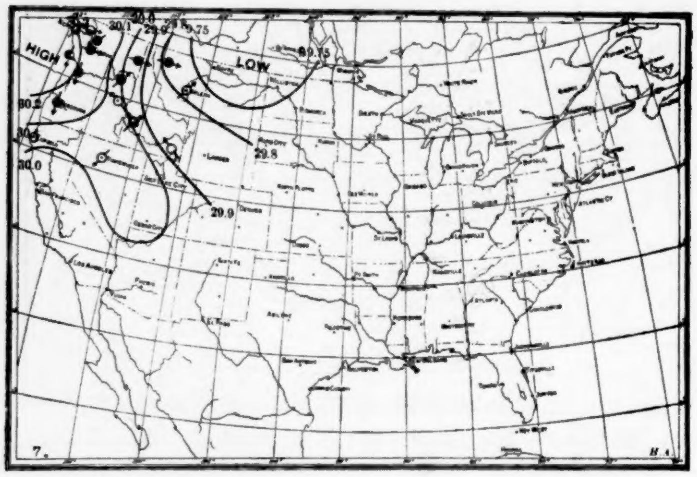


FIG. 7.—Columbia fire. Map for Sept. 7, 1894, 8 a. m., 75th mer. time. — isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

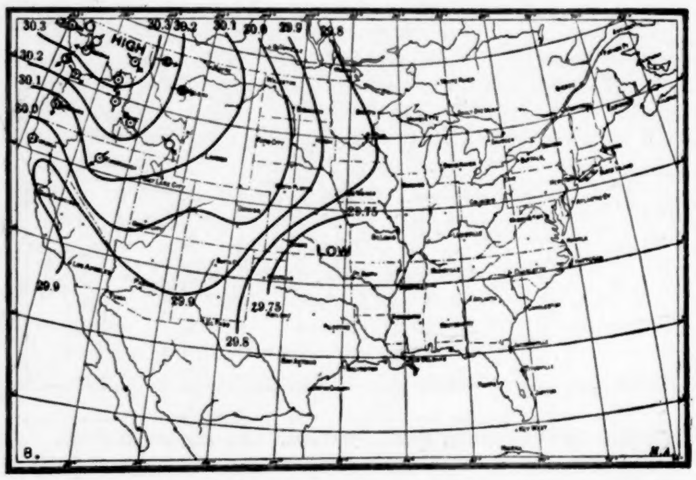


FIG. 8.—Columbia fire. Map for Sept. 8, 1902, 8 a. m., 75th mer. time. — isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

Northern Rocky Mountains and also in the Cascade Range of Mountains. Fires occurred in May and June in the drainage areas of the Cœur d'Alene and St. Joe Rivers, but there were no large fires in this section until July 9, when one broke out back of Turner Bay on Coeur d'Alene Lake. From this time on one fire after another was reported by the forest patrols until as many as 15 large fires were burning at one time. They were kept under fair control until August 20, when a hot, high wind from the southwest began to blow, which quickly spread the fires beyond the trenches, and they burned so furiously

nothing could be done to stop them. By the evening of the 21st the weather became more favorable, and as the fires had practically burned themselves out no great damage was done after this date, although they kept burning until about September 1, when rain fell and put them out.

From information received from the officials in charge of the local offices of the Weather Bureau in Helena, Mont., and Boise, Idaho, the weather conditions leading up to the great Idaho fire were as follows: The snowfall during the winter of 1909–10 was less than usual, and the heaviest deposits were in February. The following March was a very warm month, and the snow by the 1st of April had disappeared at high elevations and in forests where generally snow is found until June. The following months were warm and the rains were light, which caused the humus in the forest and the grass on the hills and mountains to dry out much earlier than usual. Only about 35 per cent of the normal amount of rain fell in June, and by July the forested sections were generally as dry as tinder, and fires would start on slightest provocation.

The following table shows the departures from the normal temperature and precipitation in northern Idaho and western Montana from March to April, 1910, inclusive:

Month.	Temperature departures.		Precipitation departures.	
	Northern Idaho.	Western Montana.	Northern Idaho.	Western Montana.
1910.	° F.	° F.	Inches.	Inches.
March	+5.5	+7.4	+0.36	−0.08
April	+4.3	+5.6	+ .60	− .13
May	+2.9	+2.3	+ .02	− .43
June	− .4	+1.7	−1.18	−1.29
July	+1.5	+2.0	− .76	− .70
August	−2.5	−2.1	− .72	+ .02

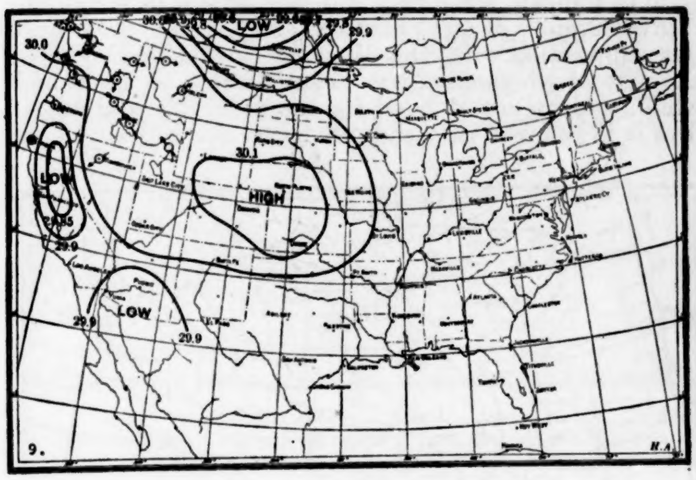


FIG. 9.—Columbia fire. Map for Sept. 9, 1902, 8 a. m., 75th mer. time. ▬ isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

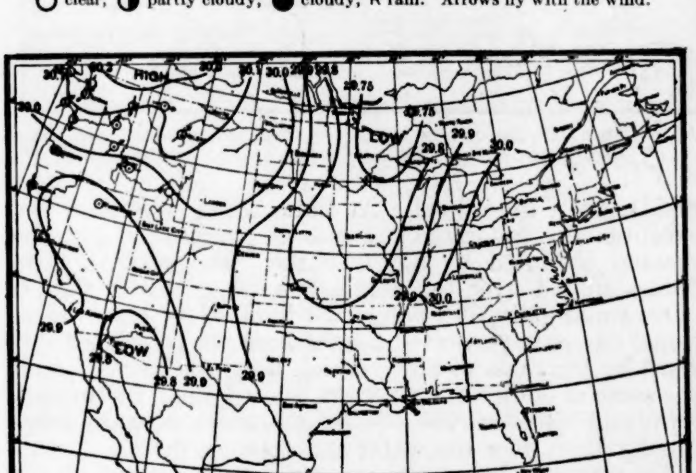


FIG. 10.—Columbia fire. Map for Sept. 10, 1902, 8 a. m., 75th mer. time. ▬ isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

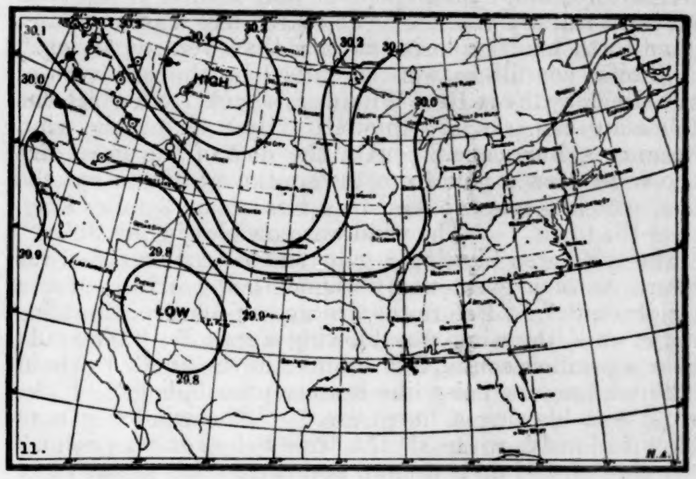
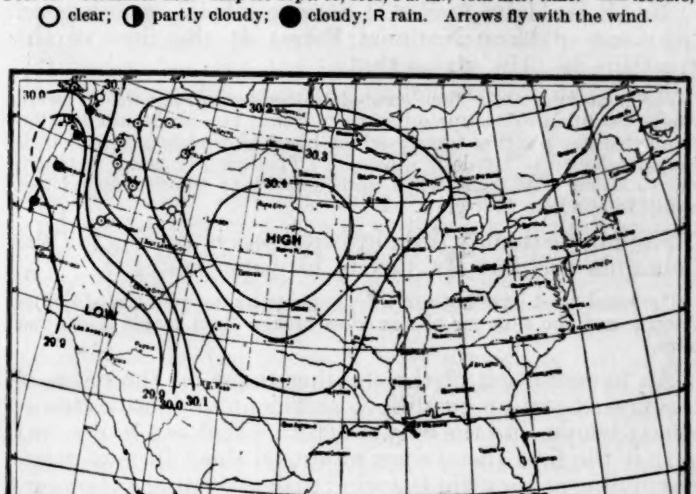


FIG. 11.—Columbia fire. Map for Sept. 11, 1902, 8 a. m., 75th mer. time. ▬ isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.



FIG· 10—Columbia fire. Map for Sept. 12, 1902, 8 a. m., 75th mer. time. ▬ isobars; ◯ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

Figures 13, 14, and 15 illustrate the meteorological conditions just preceding and during the period the fires were beyond control.

GENERAL CONCLUSIONS.

One striking feature of all large forest fires is the strong winds that prevail just before, during, and for a short period after the fire passes a given place.

In the report on the Michigan fire by Sergt. Bailey he quotes from the survivors such expressions as the follow-

ing: "Fire was driven by strong changing winds that grew to be gales as the flames advanced." "All day Sunday the wind was in the southwest and was very hot. The next day toward noon the wind increased to a dangerous gale, changing to almost a west wind." "The southwest gale that blew the fires into Huron Township was sufficiently strong to prostrate trees 30 feet high and 6 or 8 inches in diameter." "The whirlwind that carried the fire into and through Huron City seems to have hugged the country adjoining the lake coast." "Wind was strong enough to tear the roofs from barns, to throw down log houses, and to lift persons from the ground and hurl them short distances through the air." "The strength of the southwest current may be judged from the fact that in Sherman township it caught up a wagon weighing 1,000 pounds and hurled it 15 rods across a railway track." "It roared like a tornado and gave forth loud explosive sounds that were terrifying."

Similar conditions were described by the survivors of the Hinckley fire in Rev. Wilkinson's book, from which the following remarks are quoted: "By 2 p. m. the wind became a hurricane." "On the day of the great fire the wind blew a gale from the southwest and swept the fire, which seemed formed in a line about 3 miles long, over the town." "The wind was now blowing fearfully." "The wind was blowing a gale, and a terrible noise was heard, as of a great many wagons being driven over a rough road." "Before the fire we could hear a rumbling noise, as if the wind was blowing a gale." "We could hear a peculiar sound, like thunder in the air." "About 5:30 we heard a noise like lumber piles falling." "The wind was blowing a hurricane." "The wind began to blow furiously, while all the time before it was calm." "A gust picked up a woman and carried her about 25 or 30 feet, when she was dropped among some cornstalks."

Mr. J. B. Halm, a Forest Service official, who was on the Cœur d'Alene National Forest at the time of the great fire in 1910, states that:

> The heat from these fires created tremendous drafts which swept whole mountain sides, uprooting every tree. This draft in every instance became a sort of tornado which blew the timber in great whirls from one-fourth to 1 mile in diameter. This wind in many instances was so strong that trees, when uprooted, where thrown several feet uphill from where they grew.

Similar testimony from eyewitnesses is lacking for the Columbia fire, but Mr. Cox in his paper states:

> The wind must have been terrific, to judge by the quantity of timber thrown and the number of branches broken from maple and other trees.

An examination of the weather maps on the dates of the fires shows no conditions sufficient to cause extraordinary winds, and the only conclusion that can be reached is that the fires themselves produced these furious gales, resembling as they did the wind rush attending a thunderstorm or the violent whirl characteristic of the tornado. Every condition was there, except moisture, to produce local thunderstorms or even tornadoes, and the atmospheric movements were probably much the same as those taking place when true sand storms prevail in desert countries, where strong convectional currents cause unstable equilibrium, and whirls are generated that may have a vertical or a horizontal axis.

The convectional currents caused by a forest fire are much stronger than those produced by the sun warming a sandy surface, but the mass of air warmed by a forest fire is generally smaller, and therefore the wind would be more energetic within the field of action and not greatly disturbed elsewhere. That it is not greatly disturbed elsewhere is proven by the maximum wind velocities recorded at near-by places, which are shown in Table 2:

TABLE 2.—*Maximum wind velocities at near-by stations.*

Name of fire.	Maximum wind.	Direction.	Place.	Distant.
	Miles per hour.			*Miles.*
Michigan	25	W	Port Huron	40
Hinckley	20	S. W	Duluth	70
Columbia	24	N. E	Portland	30
Idaho	23	S. W	Spokane	55

Forest fires do not spread nearly as rapidly as the speed of the wind in the neighborhood of the fire would seem to indicate, for if they did they would travel at the rate of 80 miles or more an hour, and that is a preposterous supposition. In the Michigan and Hinckley fires the rate of progression was about 8 miles an hour, and while no data are at hand for the Columbia and Idaho fires it is believed they did not travel much if any more

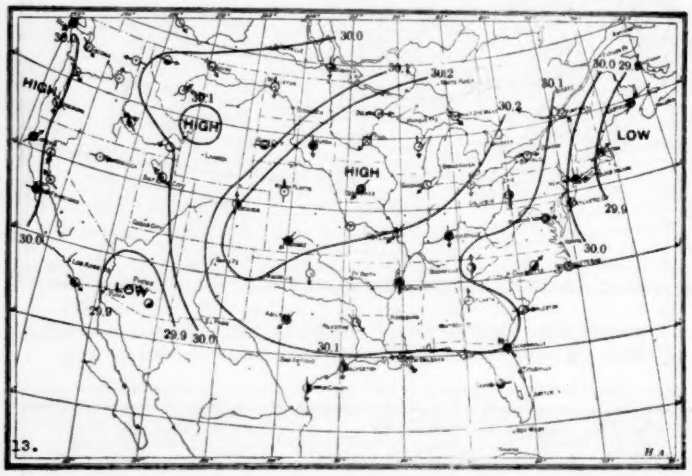


FIG. 13.—Great Idaho fire. Map for Aug. 19, 1910, 8 a. m., 75th mer. time. ▬ isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

rapidly than the others. At times when conditions are exceptionally favorable the rate of progression may be greater, as noted by Sergt. Bailey, who stated, "The flames spread over the parched meadows faster than a horse could gallop." The whirls induced by the convectional currents generated by the fires are translated forward by the mass of air in which they are formed much the same as eddies in a river are carried along by the current, and these eddies at no time move forward more rapidly than does the water surrounding them.

No weather forecaster can predict the speed of the wind in close proximity to a fire, for that, as we have seen, is a local condition depending on the amount of heat created, which in turn causes the convectional currents that disturb the equilibrium of the atmosphere. The translatory movement of the atmospheric mass, however, can be predicted within a reasonable degree of accuracy and the problem then becomes one of determining how rapid the translation of the whole mass of air must be to cause a forest fire to spread beyond control.

The air was remarkably hot and stagnant for a week or more preceding the Michigan fire, except on one occasion about five days before it broke out. The winds on this day, August 31, 1881, were a little stronger than they had been, but not strong enough to cause a general con-

flagration. A weak, low pressure area was central north of Lake Huron and a thunderstorm developed over lower Michigan which advanced eastward to the Canadian Province of Ontario. The rainfall was light and the wind rush attending the storm caused one fire to increase in size and to spread through several townships. The maximum wind velocity on this day at Port Huron was 42 miles from the south, while on the day of the great conflagration the maximum velocity at the same station was 25 miles from the west. The total 24-hour movement at Port Huron was 233 miles on the day of the small

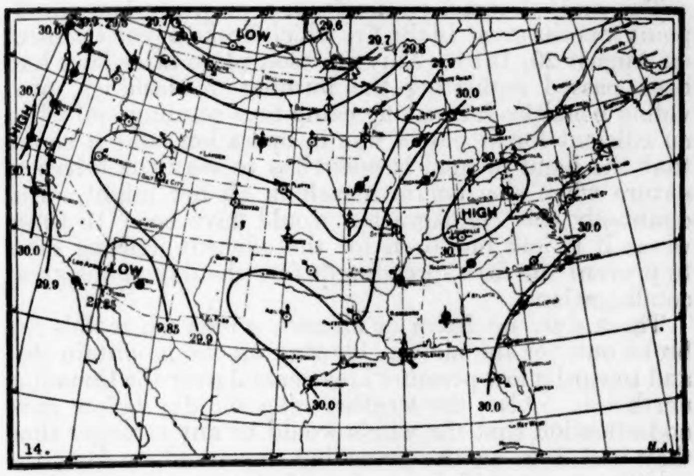


FIG. 14.—Great Idaho fire. Map for Aug. 20, 1910, 8 a. m., 75th mer. time. —— isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

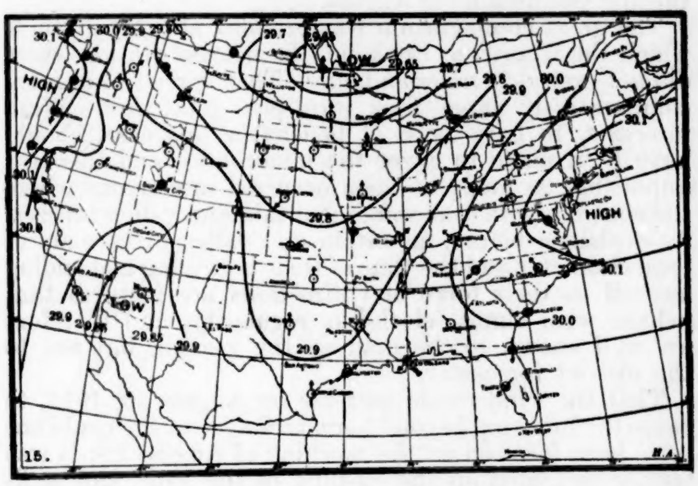


FIG. 15.—Great Idaho fire. Map for Aug. 21, 1910, 8 a. m., 75th mer. time. —— isobars; ○ clear; ◑ partly cloudy; ● cloudy; R rain. Arrows fly with the wind.

fire and 331 miles on the day of the large fire. In the one case the average hourly velocity was 10 miles and in the other 14 miles.

It is not safe to conclude from these data that an average hourly velocity of 10 miles will cause a fire to spread over a small area, and 14 miles will cause one to spread over a large area, for in the first place the average velocity might be quite different from the actual velocity when the fires were spreading most rapidly, and in the second place the direction of the wind might materially change the result. If the direction was such as to cause a back fire it would operate to check spreading, or if the direction was toward an open country there would be no fuel for the flames, and consequently the fire instead of spreading would be held back.

For a week preceding the Hinckley fire the air was also remarkably stagnant, the greatest 24-hour wind movement at St. Paul, Minn., being 149 miles on August 28, 1894, which is an average of only 5 miles an hour. On the day of the fire the 24-hour movement at the same station was 219 miles, which is an average of 9 miles an hour. This is about the same velocity as that which caused the first Michigan fire to spread over several townships, and it is believed with other conditions favorable a velocity of about 10 miles an hour is an extra hazardous wind for spreading forest fires in a level country, and that whenever they are expected those interested in forest fire protection should be advised as far ahead of their coming as possible. It then becomes a matter for the forest officials to judge whether the direction of the expected winds is such as to make it necessary for them to redouble their efforts in checking the spread of the flames, or whether the increase in the velocity will be offset by a change in direction and the fires abate rather than increase in size. This point is obviously one that the forecaster could not be expected to know about, but it is a vital one in interpreting a wind forecast, whether made for mariners or landsmen.

It is quite probable that the Michigan and Hinckley fires could easily have been prevented by modern fire-control methods, but at the time they occurred there were no laws to stop the burning of slashings, which were burned whenever and wherever owners saw fit, and there were no organized fire patrols or any systematic efforts made to check the spreading of dangerous fires. It is reported that the settlers in Michigan were busily engaged in clearing their land with local fires on the very day the great conflagration started and destroyed everything they had except the bare land. To a slightly less degree the same conditions prevailed in Minnesota at the time of the Hinckley fire, but the Columbia fire and especially the Great Idaho fire occurred under entirely different conditions.

When the Columbia fire took place the Forest Service had just been organized and the timbermen in the North Pacific States were beginning to realize the necessity of taking systematic measures to prevent the destruction of the standing timber by fire. Conservation forces then were not organized as they are now, and it is possible the Columbia fire would not have gained the headway it did under the present system of fire control, but the weather conditions leading up to it were almost as bad as they could be and no worse are likely to be met in the future.

Mr. Cox in his description of the conditions leading up to this fire mentioned the fact that the wind blew from the east and that this wind after it gets west of the Cascades is ready to absorb any quantity of moisture. His statement is corroborated by the charts illustrating the meteorological conditions prevailing at that time, and an explanation is necessary to show why an east wind is so dry and dangerous.

The Columbia fire occurred at the base of the Cascade Mountains on the west side of the range. The east wind that blew consisted of air overlying, for the most part the treeless plateau of eastern Washington which was forced up the east side of the range and down the west side. The elevation of the eastern Washington plateau will average about 1,500 feet, while the elevation of the district where the fire occurred is probably less than 500 feet. Air when forced up a mountain side cools at the rate of 1.6° F. per 300 feet and when flowing down the

other side it is being compressed and it grows warmer at the rate of 1.6° per 300 feet. The average altitude of the crest of the Cascades is not far from 4,500 feet. Air overlying the eastern Washington plateau in the early part of September has a normal temperature of about 68° and that was about the temperature prevailing when this east wind was blowing. It ascended about 3,000 feet and descended about 4,000 feet; therefore, if no other complications occurred, it was about 5° warmer when it reached the lower level on the west side of the range. This would make the mean temperature 73° with probably a maximum of 90° and a minimum of 56°.

The amount of water vapor that it is possible for air to contain depends on the temperature. At zero temperature it can contain 0.54 grain per cubic foot; at 30°, 1.97 grains per cubic foot; at 60°, 5.76 grains per cubic foot; and so on, increasing at a rapid rate. As a matter of fact the air seldom contains all the water vapor it is capable of holding and during a hot day in the subarid region of eastern Washington there is only about 40 per cent of the possible amount. It is probable that the humidity was not greater than 40 per cent when the east wind that Mr. Cox mentions was passing over eastern Washington, and when it reached the other side of the Cascade range of mountains and the temperature was increased by 5° as explained in the preceding paragraph, the humidity would be 34 per cent, which indicates there was only about a third of the moisture present that it was possible for the air to contain. Under these conditions evaporation takes place rapidly, especially if a fresh breeze is blowing and the desiccating effects of the atmosphere are very great.

Winds of this character are called fœhn winds in Switzerland and chinook winds in the United States. They excite more attention in winter than during the other seasons, for then great quantities of snow are often evaporated in a few hours, and its disappearance attracts the attention of everyone. In some parts of Switzerland it is said fire patrols go quickly from house to house when these winds begin to blow, in order to be sure that the fires have been extinguished, for great conflagrations may easily occur at such times owing to the drying of the wood by the wind.

Owing to the mountainous nature of the country where the Columbia fire occurred, weather data from a nearby station do not reflect the conditions prevailing in the immediate proximity of the fire so well as in the case of the Michigan and Hinckley fires where the country is comparatively level, but as no other data are available it is necessary to use those for Portland, Oreg., a station some 30 miles or so to the west of the fire.

For three weeks preceding this fire the atmosphere was remarkably quiet, with the usual summer northwest monsoon winds prevailing. During this time the greatest 24-hour wind movement was 183 miles on September 5 and the maximum wind velocities for each 24 hours did not exceed 19 miles, and generally they were not greater than 12 or 14 miles. On September 8 the wind increased and the direction changed to northeast. The maximum velocity on that day was 24 miles and the total movement was 253 miles. This was the wind that caused the fires to spread beyond control. It will be noticed that the average hourly velocity was between 10 and 11 miles an hour, which approximates the velocities prevailing when the Michigan and Hinckley conflagrations were under good headway. Also the maximum velocity was about the same as during the other two fires. There was a vast difference, however, in the character of the wind as regards dryness, and there might have been a greater difference in velocity due to the ruggedness of the topography in the vicinity of the Columbia fire. Also the winds during the Columbia fire were blowing out from a high pressure area and those at the time of the Michigan and Hinckley fires were blowing in toward the center of a low pressure area, which denotes independently of topography that they were ascending winds in the latter case and descending in the former. Just what bearing this fact would have in propagating forest fires the writer does not know, but it is a matter to be considered in questions of this character.

The most destructive fire from a property loss standpoint was the great Idaho fire which broke beyond control on August 20, 1910. This fire took place after laws had been passed regulating the burning of slashings, providing penalties for leaving camp fires burning and when an efficient forest patrol was in operation, and it shows that the hand of man is powerless to stay the forces of nature when she asserts herself in all her might. Undoubtedly this conflagration would have been 10 times worse if it had not been for the efficient fighting done to prevent the fires spreading before the day of the great conflagration.

There were no fœhn or chinook winds when this fire broke out, for the air was blowing up the mountain side and toward a low pressure area central over the Canadian northwest. Also, the weather map the day before gave no indication that the winds would be any stronger than they had been on the preceding days, and, in fact, the weather map on the morning of the fire did not show that any stronger winds should be expected than on several occasions during the last half of July and during the first two decades of August.

The great conflagration was brought about by winds which the records at Spokane, the nearest station, show did not exceed 23 miles an hour. They spread 15 or more comparatively large fires into one great fire. Wind forecasts, to have been of benefit in this case, should have been made to cover the minor fires, and this was impossible, as many of them occurred in canyons where the controlling factors were mountain and valley breezes. As explained before, mountain and valley breezes are of local character and the time of their beginning and ending as well as their force and directions are features that behave with almost clock-like regularity, and therefore are well known to the man on the ground, but not to the district forecaster.

That the wind would increase on August 20, 1910, to cause the breaking beyond bounds of a forest fire could not have been foreseen on the morning of August 19; it was faintly indicated on the evening of the 19th, and sufficiently pronounced on the morning of the 20th to warrant a warning being issued, but then it was too late to have done any good. Furthermore, it was only in that particular section that winds of more than ordinary strength could be expected, and for this reason the district forecaster ought to be kept advised regarding the localities where there is the greatest danger of forest fires spreading beyond control, for then he could concentrate his attention on those places.

As the time is short in which the forecaster must act, and it is the desire of the Weather Bureau that the information available be disseminated so as to do the greatest good to the greatest number, it is evident that wants and localities should be designated in detail so that he can give his undivided attention first to those matters that are most pressing, and then to the others in the

order of their importance. After a warning is issued it is of equal importance that it be disseminated as quickly as possible, for failures to profit thereby are as apt to occur through the late receipt of the warning as they are in any other way.

In conclusion, it is thought that an intelligent use of the facilities of the Weather Bureau would be of assistance to those engaged in fighting forest fires, but where forests are situated near the sea, or in a mountainous country, there are so many local controls to wind movement that much will have to be left to the man on the ground. The subject is certainly worthy of further study which it is believed should be jointly done by specialists in both branches of the work, that each might have a better understanding of the limitations of the other in reaching their conclusions.

SECTION IV.—RIVERS AND FLOODS.

THE RIVERS DURING FEBRUARY.

By ALFRED J. HENRY, Professor of Meteorology.

The weather during February was not favorable to the production of floods. Northern streams were icebound and there were no excessively heavy rainfalls to swell southern streams, except as noted below. Warm weather caused the melting of some snow in the Ohio Valley watershed on the 18th and 19th, resulting in freshet stages in the Evansville (Ind.) district only. The highest stage at Evansville was 33.7 feet on the 25th. (Flood stage 35 feet.)

A rainy period in California from the 18th to the 21st caused the upper Sacramento to pass above the flood stage at Red Bluff on the 21st, Jacinto on the 22d, and Colusa on the 23d. On the lower San Joaquin flood stage was passed at Lathrop on the 23d and on the Mokelumne at Bensons Ferry on the 22d.

Heavy rains over North Carolina on the 20th caused the Roanoke River to pass the flood stage at Weldon, N. C., on the 22d, the Neuse to pass the flood stage at Smithfield on the 22d, and the Cape Fear River to pass the flood stage at Fayetteville on the same day. These rises were of short duration and caused comparatively little damage.

At the close of the month the tributaries of the Mississippi were at moderate stages and well able to carry off any sudden inflow of rain or melting snow.

The flood damage during February is shown below:

Money loss by flood.

Sacramento (Cal.) district:	
Tangible property, buildings, highways, levees, etc.	$61,000
Farms and farm property, including prospective crops	15,000
Stock and movable property	10,000
Total	86,000

SNOWFALL IN HIGH ALTITUDES, FEBRUARY, 1914.

California.—The snowfall during the month was slightly below the average and was confined to the higher levels. From 5,000 feet up in the Siskiyou and northern Sierra and above 6,000 feet in the southern Sierra and Sierra Madre there is a large amount of well-packed snow on the ground, with a high water content. Nearly every storm of the winter has been followed by rain extending often to 7,000 and 8,000 feet, and later by clear, cold weather, giving the snow fields a coating of ice which, under ordinary conditions, will prevent melting until late in the spring or summer. Present conditions indicate abundance of water for power purposes and irrigation during the coming season.

Snow density in California.—A few measurements of the density of snow at different parts of the State were made by weighing a cubic foot of snow. The water content of the snow was found to vary from 26 per cent to 59 per cent, the latter value, however, was found at the bottom of a 15-foot layer of snow at Summit, Cal., where a cubic foot taken from the surface weighed 21½ pounds, corresponding to a water equivalent of 34 per cent; a cubic foot taken at a depth of 64 inches weighed 28 pounds, corresponding to a water equivalent of 45 per cent, and finally a cubic foot taken at a depth of 174 inches or practically the bottom of the layer, weighed 36¾ pounds, corresponding to a water content of 59 per cent as above.—*G. H. Willson, Local Forecaster.*

Oregon.—Some snow fell in the Cascade and Siskiyou Mountains, and amounts ranging from 1 inch to over 4 feet were recorded at scattered stations in the Blue Mountains; elsewhere in the section little or no snow was reported.

At the end of February, compared with last year, there was less snow below the 4,000-foot level in practically all of the mountain ranges, while some stations above that elevation reported more.

Compared with the normal there was more snow than usual in the higher altitudes, but below 4,000 feet elevation there was generally less than the average amount on the ground at the end of this month.

The snow now appears to be well packed, in some instances having the consistency of ice.—*E. A. Beals, District Forecaster.*

Utah.—There was much less precipitation during February than in the preceding month and less than the normal amount. The month was mild and during the warm spells some of the snow in the valleys melted, uncovering the range land, and also caused further settling and packing of the greater depths in the mountains. However, in spite of the deficient snows during February, and the loss by melting, the reports are unanimous for an abundant water supply during the coming growing season.

In the Great Salt Lake Watershed the amounts in the hills and mountains ranged from 12 to 108 inches. In the Sevier Lake Watershed very little snow fell in the valleys, but some snow was added to the already considerable depths in the mountains, where it was well packed, the amounts ranging from 10 to 75 inches. The depth in the Green and Colorado Rivers Watershed ranged from 6 to 72 inches, the snow was well drifted and packed in nearly every locality.—*A. H. Thiessen, Section Director.*

Montana.—The snowfall for February was somewhat greater in the mountain districts of Montana than for either December or January preceding. It was, however, somewhat below normal in the mountain ranges east of the Continental Divide, but was normal or above over most of the Columbia drainage.

Considering only the amount of moisture stored in the mountains as snow, the outlook for a late water flow in the streams is less favorable than for several years.—*R. F. Young, Section Director.*

Wyoming.—An average snowfall of 9.2 inches for the State during the month of February was 0.7 inch below normal. In portions of the State, where the normal fall

was exceeded, in the lower elevations of the northeast accumulations of snow are of little value for purposes of irrigation; besides, moderate temperatures caused much of the snowfall in that section to disappear. At the higher elevations conditions were less favorable generally than at the close of the preceding month. On the Medicine Bow Range, watershed of the North Platte, and at Bechler River station, headwaters of the Snake River, conditions have improved. On the mountains adjacent to the latter point depths of 10 feet are reported. Depths of 6 feet are reported in the southwestern portion of Albany County. Accumulated depths on the watersheds of the North Platte, Green, and Snake Rivers promise sufficient water for the coming season; conditions on the Yellowstone Watershed are less promising, while on the watersheds of the Big Horn, Cheyenne, Powder, and Tongue Rivers decidedly unfavorable conditions prevail.—*R. Q. Grant, Section Director.*

Colorado.—Weather conditions during February were not favorable to material additions to the snowfall in the mountains. There was a general deficiency throughout the State, the fall being especially deficient in the southwestern and central portions. Depths on the different watersheds at the end of February were practically the same as at the end of January, except that the water content was higher. The latter ranged from 21 to 33 per cent when exposed to the sun and somewhat less in shaded localities. Good early and late flows are indicated.—*F. H. Brandenburg, District Forecaster.*

Idaho.—The snowfall during February was lighter than usual over most of the State, and the accumulated depth in the mountains was somewhat less than at the end of January. Mild temperatures at the close of the month caused the snow at the lesser elevations to disappear rapidly, but at the greater altitudes snow was settling rather than running off. The water content is rather high, probably about 30 per cent; conditions are favorable for early melting.—*E. L. Wells, Section Director.*

Nevada.—The snowfall for February was considerably less than normal in the Humboldt and normal or above in the Carson and Walker basins.

No snow of consequence remained on the ground below the 5,000-foot level at the end of February, and but little on south and west slopes up to the 7,000-foot level. On the east and north slopes, at an elevation of 6,000 feet, there were about 75 inches of very compact snow; at 7,000 feet, from 70 inches to 184 inches; at 8,000 feet, from 110 inches to 186 inches; at 9,000 feet or more, from 96 inches to 192 inches or more of very dry snow.

There has been no run-off of consequence above 6,000 feet, leaving practically all the precipitation since September 1 on or in the ground. This has exceeded the four-year average over the entire State, and near the Sierras it was nearly twice that amount.—*H. S. Cole, Section Director.*

South Dakota.—The average snowfall during February, 1914, in the greater portion of the Black Hills district of the State was 8.3 inches. The average amount remaining on the ground on the 28th was 2.2 inches. The water from melted snow has not increased the amount present in the streams in the Black Hills district.—*S. W. Glenn, Section Director.*

Arizona.—At the end of February, 1914, the higher levels of the White Mountains and the northern portion of the Blue range were covered to a depth of about 4 feet. There is little snow on the south slopes below the 9,000-foot line, while at that height on the north sides 6 to 21 inches remain. On the Santa Teresa, Graham, and Chiricahua Mountains the snow ranges from a trace at the 8,500-foot level on the north slopes to 3 or 4 feet on the peaks.

The Mogollon Mesa is well covered with snow, but it is not deep for the season. The higher slopes of the San Francisco Mountains hold from 6 to 10 feet, and on the Colorado and Kaibat Plateaus 2 to 4 feet of snow remain at elevations above 8,000 feet.—*Robert W. Briggs, Section Director.*

Washington.—On account of the general mildness of the month the snow did not accumulate in depth; at the end of the month it was less than on the 15th and was nearly everywhere less than the average.—*G. N. Salisbury, Section Director.*

SECTION V.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Junior Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Alsace-Lorraine. Meteorologische Landesanstalt.
Deutsches meteorologisches Jahrbuch für 1911. Elsass-Lothringen. Strassburg i. E. 1913. viii, 59 p. f°.

Arnauld, Henri.
L'aurore boréale. Aurore et crépuscule, lumière zodiacale (1884-1913). Bordeaux. 1913. 77 p. 8°.

Ballantyne, A. B.
Blooming periods and yields of fruit in relation to minimum temperatures. Logan, Utah. 1913. 245-261 p. 8°. (Utah agricultural experiment station. Bulletin 128)

Alvord, [John W.], & Burdick, [Charles B.]
A report to the mayor and city council on flood protection for the city of Columbus, Ohio, September 15, 1913. Chicago. [1913] [xi], 325 p. plates. 8°. [Contains description of the rainstorm of March, 1913, the flood of 1913, etc.]

Denmark. Meteorologiske institut, & Hamburg. Deutsche Seewarte.
Tägliche synoptische Wetterkarten für den Nordatlantischen Ozean. 27. Jahrgang. (Dezember 1907 bis Mai 1908) Copenhague, *etc.* 1913. 2 v. f°.

Eiffel, G[ustave].
Atlas météorologique pour l'année 1912, d'après vingt-cinq stations françaises. (Septième année) Paris. 1913. portfolio: text; atlas in 2 parts. f°.

Gordon, William.
The place of climatology in medicine. Being the Samuel Hyde memorial lectures read before the Section of balneology and climatology of the Royal society of medicine, May 20th and 21st, 1913. London. 1913. 2 p. l., 62 p. 8°.

Hamburg. Deutsche Seewarte.
Deutsches meteorologisches Jahrbuch für 1912. Jahrgang 35. Hamburg. 1913. vii, 176 p. f°.

Hellmann, G[ustav].
Regenkarten der Provinzen Schleswig-Holstein und Hannover sowie von Oldenburg, Braunschweig, Hamburg, Bremen, Lübeck und vom Harz, mit erläuterndem Text und Tabellen. 2. vermehrte Auflage. Berlin. 1913. 36 p. maps. 4°.

Henshaw, F. F., & Parker, G. L.
Surface water supply of Seward Peninsula, Alaska. Washington. 1913. 317 p. maps, plates. 8°. (U. S. Geological survey. Water-supply paper 314) [Climate, p. 15-32]

Hoyt, William Glenn.
The effects of ice on stream flow. Washington. 1913. 77 p. plates. 8°. (U. S. Geological survey. Water-supply paper 337)

Huber, Anton.
Das Klima der Zugspitze. München. 1914. 62 p. f°. (*S.-A.* Beobachtungen der meteorolog. Stationen im Königreich Bayern, von der K. B. Meteorolog. Centralstation. Band 35. Jahrg. 1913)

Hunter, J. de Graaff.
Formulæ for atmospheric refraction and their application to terrestrial refraction and geodesy. Dehra Dun. 1913. v, 114 p. plates. 4°. (India. Trigonometrical survey. Professional paper no. 14)

Italy. R. Istituto idrografico.
Riepilogo annuale delle osservazioni meteorologiche fatte durante l'anno 1913. Genova. 1914. [13] leaves. f°.

McAdie, Alexander G[eorge].
The rainfall of California. Berkeley. 1914. 127-240 p. pls. 21-28. (University of California publications in geography, 1914, vol. 1, no. 4)

Müntz, A., & Lainé, E.
Études sur les eaux météoriques, sur le sol et sur l'atmosphère, exécutées aux stations d'observation de la mission Charcot. (*In* Annales de l'Institut national agronomique. 2 sér., tome 12, fasc. 2. Paris. 1913. p. 179-231)

Radcliffe observatory, Oxford.
Results of meteorological observations . . . 1913. Vol. 51, pt. 3. Oxford. 1914. 41-60 p. 8°.

Rohrbeck, W.
Hagel, Hagelschädenbeurteilung und Hagelversicherung. Berlin. 1913. 36 p. 8°. (Landwirtschaftliche Hefte, 23)

Schmauss, August.
Die Münchener Registrierballonfahrten im Jahre 1913. Mit einem Anghang: 1. Auswertung der am 25. V. 1913 aufgefundenen Regristrierung vom 3. I. 1912. 2. Allgemeine Ergebnisse der Fahrten von 1906-1913. München. 1914. 53 p. (*S.-A.* Beobachtungen d. meteorolog. Stationen im Königreich Bayern, von d. K. B. Meteorolog. Centralstation. Band 35. Jahrg. 1913)

Schmidt, Wilhelm.
Vergleiche zwischen den Hauptbarometern der meteorologischen Zentralinstitute in Wien, Budapest, Belgrad, Sofia, Bukarest, Athen und Rom. Ausgeführt in den Jahren 1910 und 1911. Wien. 1913. 12 p. f°. (*S.-A.* Jahrbücher d. K. K. Zentralanst. f. Meteor. u. Geod., Jahrg. 1911)

Schwalbe, G.
Das Klima von Mecklenburg auf Grund neuerer Untersuchungen. Mit 6 Karten. Rostock. 1913. 1 p. l. 13 p. plates. 8°.

Sperer, Martin.
Der Campbell-Stokessche Sonnenscheinautograph nebst Bemerkungen zur Frage der photographischen Sonnenscheinregistrierung. 1. Teil. Amberg. 1913. 25 p. 8°. (Programm des K. humanist. Gymnasiums Amberg 1912/13)

Stonyhurst college observatory, [Lancashire].
Results of meteorological, magnetical, and seismological observations, 1913. Liverpool. 1914. xiv, 56 p. 12°.

Tilton, John L[ittlefield].
Outline for the study of meteorology. Indianola, Ia. [°1914] 1 p. l., 18 p. 8°.

U. S. Bureau of standards.
The testing of barometers. (1st edition) Issued February 1, 1914. Washington. 1914. 12 p. 4°. (Circular no. 46)

Upsala. Observatoire météorologique de l'université.
Bulletin mensuel. Vol. 45. Année 1913. Par F. Åkerblom. Upsala. 1913-14. 1 p. l., 73 p. f°.

Vaucluse. Commission météorologique.
Compte-rendu pour l'année 1912. Avignon. [1913] 32 p. f°.

Wallén, Axel.
Fleråriga variationer hos vattenståndet i Mälaren, Nederbörden i Uppsala och lufttemperaturen i Stockholm. [Swedish text; French résumé]. Stockholm. 1913. 2 p. l., 104 p. 4 pls. f°. (Meddelanden från Hydrografiska byrån. 4)

Wentworth, B. H.
A chart of Maine winters, 1785 to 1913, from Kennebec river records and daily observations at Gardiner, Maine. Gardiner. 1914. chart, 29 x 37½ cm.

Westman, J.
Beobachtungen über den Wasseraustausch zwischen der Schneedecke und der Luft im mittelschwedischen Tieflande. Stockholm. 1913. 2 p. l., 26 p. f°. (Meddelanden från Hydrografiska byrån. 5)

Zistler, P., & Bux, K.
Münchener Pilotballonbeobachtungen im Jahre 1913. München. 1914. 31 p. f°. (*S.-A.* Beobachtungen der meteorolog. stationen im Königreich Bayern, von der K. B. Meteorolog. Centralstation. Band 35. Jahrg. 1913)

RECENT PAPERS BEARING ON METEOROLOGY.

C. FITZHUGH TALMAN, Junior Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Aeronautics. London. v. 7. March, 1914.
Gulls and eddies. p. 82.

American geographical society. Bulletin. New York. v. 46. February, 1914.
Condra, G[eorge] E[veret], & Loveland, G[eorge] A. The Iowa-Nebraska tornadoes of Easter Sunday 1913. p. 100-107.
Ward, Robert De C. A note on the classification of climates. p. 108-116.

Engineering news. New York. v. 71. 1914.
Snowfalls and street cleaning. p. 471. (Feb. 26.)
Temperature measurements on a concrete building. p. 606-607. (Mar. 19.)

Geographical journal. London. v. 43. February, 1914.
Gregory, J. W. Is the earth drying up? p. 293-318. [Bibliography, p. 308-313.]

International institute of agriculture. Bureau of agricultural intelligence and plant diseases. Monthly bulletin. Rome. 5th year. February, 1914.
Livingston, B. E., & Livingston, G. J. Temperature coefficients in plant geography and climatology. p. 191. [Abstract from Botanical gazette.]

Nature. London. v. 92. 1914.
Antarctic problems. The problem of the antarctic Andes and the antarctic horst. p. 700-702. (Feb. 19.) [Includes discussion of meteorological problems.]
Mallock, A. Weather forecasts in England, p. 711-712. (Feb. 26.) [An unfavorable criticism of weather forecasts in general.]
S[haw], W. N. Daily synoptic charts of the northern hemisphere and absolute units. p. 715-716. (Feb. 26.)
Bemmelen, W. van. Remarkable upper-air records at Batavia. p. 5-6. (Mar. 5.)
Braak, C[ornelis]. The vertical temperature distribution in the atmosphere. p. 6-7. (Mar. 5.)

Physical review. Lancaster, Pa. 2 ser. v. 3. January, 1914.
Miller, Eric R. Evidence of a diurnally reversing convectional circulation of the atmosphere over the upper peninsula of Michigan. p. 62-63.

Popular science monthly. New York. v. 84. April, 1914.
Lee, Frederic S. Fresh air. p. 313-329.

Royal meteorological society. Quarterly journal. London. v. 40. January, 1914.
Dines, W[illiam] H[enry]. The daily temperature change at great heights. p. 1-11.
Harries, Henry. Eddy winds of Gibraltar. p. 13-32.
Mossman, R[obert] C., & Salter, Carle. Great rainstorm at Doncaster on September 17, 1913. p. 33-42.
Church, J. E., Jr. Recent studies of snow in the United States. p. 43-52.
Brooks, Charles E. P. The meteorological conditions of an ice-sheet and their bearing on the desiccation of the globe. p. 53-70.
Bruce, Eric Stuart. Curious mirage of the sun seen at Ostend, September, 1907. p. 73.

Science. New York. v. 39. March, 1914.
Abbot, C[harles] G[reeley]. The solar constant of radiation. p. 335-348.

Scientific American. New York. v. 110. 1914.
Edholm, C. L. How's the weather up there? p. 183. (Feb. 28.) [Popular account of sounding-balloon observations made at Avalon, Calif.]
Waterspouts. p. 193. (Mar. 7.)
Economy in the Philippine weather bureau. p. 194. (Mar. 7.)
McAdie, Alexander. The storm of March 1st, 1914, measured in new units. p. 238. (Mar. 14.)

Scientific American supplement. New York. v. 77. February 28, 1914.
Optical marvels in the Antarctic. Light-pillars, coronas, auroras and mirages that greet the southern explorer. p. 132.

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U. S. office of experiment stations. Experiment station record. Washington. January, 1914.
Dumas, L. Rain and its measurement. p. 17.
Kroll, G. H. Wind and the plant world. p. 30. [Abstract.]

Académie des sciences. Comptes rendus. Paris. tome 158. 2 mars 1914.
Boutaric, A. Sur l'état thermique de l'atmosphère. p. 652-655.

Cosmos. Paris. 63 année. 1914.
Les résultats des niagaras paragrêles. p. 114. (29 jan.) [Failure of electric niagaras in the Nantais region.]
Nodon, A. Description d'un baromètre et d'un thermomètre datant de deux siècles. p. 131-132. (29 jan.)
La lutte contre la grêle. p. 226. (26. fév.) [Abstract of address by Angot.]

Radium. Paris. tome 2. Janvier 1914.
Boutaric, A. Sur une relation entre l'absorption de l'atmosphère et la proportion de lumière polarisée contenue dans la lumière diffusée par le ciel. p. 15-26.

Société météorologique de France. Annuaire. Paris. 62 année. Janvier 1914.
Gèze, J. B. L'humidité du sol et la météorologie agricole. p. 12-17.
Goutereau, Ch[arles.] Sur les températures supérieures ou inférieures à certaines limites. p. 18-21.

Deutsche physikalische Gesellschaft. Verhandlungen. Braunschweig. Jahrgang 15. 1913.
Lutze, G. Zusammenhang der Störungen des atmosphärischen Potentialgefälles mit den luftelektrischen Empfangsstörungen der drahtlosen Telegraphie, nach Untersuchungen am Boden und im Freiballon. p. 1100-1106. (Nr. 21.)
Kohlhörster, Werner. Messungen der durchdringenden Strahlung im Freiballon in grösseren Höhen. p. 1111-1116. (Nr. 21.)
Everling, E. Beobachtung und Theorie der durch Reflexion erzeugten Lichtsäulen. p. 1117-1119. (Nr. 21.)
Neesen, F[riedrich]. Versuche der Zentralstelle für wissenschaftlichtechnische Untersuchungen in Neu-Babelsberg über die Blitzschutzvorrichtungen für Sprengstoffanlagen. p. 1173-1180. (Nr. 22.)

Himmel und Erde. Berlin. Jahrgang 26. Februar 1914.
Hellmann, G[ustav]. Über Wetteraberglauben. p. 193-202.

K. Akademie der Wissenschaften. Sitzungsberichte. Wien. 122. Band. 1913.
Kerner v. Marilaun. Synthèse der morphogenen Winterklimate Europas zur Tertiarzeit. p. 233-298. (Feb.)
Dietzius, Robert. Die Variabilität der Steiggeschwindigkeit von Registrier- und Pilotballonen. p. 543-605. (März.)
Schmidt, Wilhelm. Luftwogen im Gebirgstal; nach Variographenaufzeichnungen von Innsbruck. p. 835-911. (Mai.)
Exner, Felix M. Über monatliche Witterungsanomalien auf der nördlichen Erdhälfte im Winter. p. 1165-1240. (Juni.)

Meteorologische Zeitschrift. Braunschweig. Band 31. Februar 1914.
Maurer, J., & Dorno, C. Über den Verlauf und die geographische Verbreitung der atmosphärisch-optischen Störung 1912-1913. p. 49-62.
Hann, J[ulius] v. Dr. G. C. Simpson: Einige Ergebnisse der meteorologischen Beobachtungen der zweiten antarktischen Expedition von Kapitän R. F. Scott. p. 62-67. [Includes data from other expeditions.]
Schmauss, A[ugust]. Ein von der Substratosphäre aus erfolgender Kälteeinbruch. p. 67-75.
Köppen, W[ladimir], & Wedemeyer, F. Beziehungen zwischen Temperatur, Luftdruck und Höhe der Troposphäre im europäischen Flachlande. p. 75-87.
Mazelle, Ed[uard]. Westbö und Springflut in Triest. p. 87-89.
Gold, E[rnest]. Atmosphärische Strahlung. p. 89-90.
Süring, R[einhard]. Merkwürdige Blitzwirkung. p. 90-91.
Henry, Alfred J. Vertikale Temperaturgradienten zwischen Mount Weather (Va.) und den Talstationen. p. 92-93.

Naturwissenschaften. Berlin. 2. Jahrgang. 1914.
Pütter, A[ugust]. Die Ausnützung der Sonnenstrahlung durch die grünen Pflanzen. p. 169-175. (20 Feb.)
Eckhardt, Wilh[elm.] Über Grundlagen und Theorien der Paläoklimatologie. p. 193-196. (27. Feb.)
Richter, Wilhelm. Über Frost- und Schneefreie Zeiten im deutschen Reiche. p. 196-199. (27. Feb.)

Physikalische Zeitschrift. Leipzig. 15. Jahrgang. 15. Februar. 1914.
Simpson, G[eorge] C. Über die Elektrizität der Niederschläge. p. 213-215.

Weltall. Berlin. 14. Jahrgang. 1. Januarheft. 1914.
Kohlhörster, W. Radioaktive Substanzen und durchdringende Strahlung in der Atmosphäre. p. 97-102; 118-122. (1. u. 2. Jan.-H.)

Wetter. Berlin. 31. Jahrgang. Februar 1914.

Lindermann, [Carl.] Die mittlere täglichen Temperaturschwankungen nach den Terminbeobachtungen an zehn Stationen des Königreiches Sachsen. p. 25–28.

Müller, A. v. Klimavergleiche einiger meteorologisch interessanten Orte von Zentral-Europa. p. 28–32.

Götz, J. Über eine merkwürdige Form von Hagelschlossen. p. 43–45.

Der Februar in Aussprüchen der ländlichen Bevölkerung. p. 48.

Zeitschrift für Balneologie. Berlin. 6. Jahrgang. 15. Februar 1914.

Hellmann, G[ustav.] Über Wetteraberglauben. p. 631–637.

R. Accademia dei Lincei. Atti. Roma. v. 23. 1914.

Tosi, A. Dispositivo herziano per osservazioni meteorologiche e previsioni di temporali. p. 84–88. (18 gen.)

Monti, V[irgilio]. Sulla distribuzione mensile della frequenza relativa della neve nelle Alpi settentrionali. p. 151–154. (1 febbr.)

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Junior Professor in Charge of Library.

RETROSPECTIVE.

In glancing back over the lustrum that has elapsed since these notes were interrupted, one is impressed by the facts that (1) there has appeared no great new trend of activity in meteorological research, comparable to the birth of aerology, as a coherent branch of science, which made the opening decade of the present century forever memorable in the history of meteorology; and that (2) the development of aerology has engrossed a major share of attention. The year 1909 was marked by the matured Humphreys-Gold explanation of what a few years ago was generally called the "isothermal layer," but is now almost universally known as the "stratosphere." The inappropriateness of the former name is illustrated by the record of a sounding balloon sent up from Batavia in December of last year. At the bottom of the stratosphere, 10.2 miles above the earth, was found the amazingly low temperature (**1**) of −90.9° C. (−131.6° F.), while above that level the temperature steadily rose to −57.1° C. (−70.8° F.) at the maximum altitude reached by the balloon, viz, 16.2 miles. This strong gradient is inconsistent with the idea of "isothermality."

A task still in progress is the determination of the relations between conditions aloft and weather changes at the earth's surface. In 1912 Dr. W. N. Shaw, director of the British Meteorological Office, introduced the idea of a "substratosphere." This he defines as "a layer of atmosphere just under the stratosphere, at the height of about 9 kilometers in the region of the British Isles, which apparently often marks the height at which the velocity of the wind is a maximum, and may be regarded as the layer of origin of the changes of pressure which are the dominant features of our weather maps." While the concluding words of the foregoing definition involve a debatable hypothesis, the notion of a transition-layer between troposphere and stratosphere seems convenient. Some characteristics of the substratosphere are discussed by Dr. A. Schmauss, director of the Bavarian meterological service, in the current number of Beiträge zur Physik der freien Atmosphäre. (Bd. 6, Heft 3.)

Yet higher "spheres" than the stratosphere still belong to the realm of speculation. In 1911 Dr. Alfred Wegener suggested that the physical characteristics of a hydrogen atmosphere such as, in view of the atomic weight of this gas, may be presumed to overlie the stratum in which nitrogen prevails, would entitle it to be regarded as a distinct "shell" of the atmosphere. At greater heights he suggests that the predominating constituent of the atmosphere may be a hitherto unknown gas, lighter than hydrogen, and perhaps identical with the hypothetical "coronium" of the solar corona. This he calls "geocoronium," and he sees in it the origin of the most conspicuous line, hitherto unidentified, in the spectrum of the aurora. He computes that geocoronium constitutes 0.00058 per cent of the atmosphere by volume at the earth's surface, but 93 per cent at an altitude of 500 kilometers. Thus the four shells of the atmosphere according to Wegener (**2**) are, in ascending order: Troposphere, stratosphere, hydrogensphere, geocoroniumsphere. Dr. O. Tetens (**3**), since the "auroral line" is also found in the spectrum of the zodiacal light, prefers to call the hypothetical light gas of the upper atmosphere "zodiacon." These speculations have been recorded here at some length on account of their prominence in current literature, but it should be noted that the "auroral line," although no longer attributed to the heavy gas krypton, is still susceptible of various interpretations, and is therefore an unsafe basis for hypotheses concerning the structure of the atmosphere. L. Vegard (**4**), who has redetermined the position of the line by observations made at Bossekop, considers it an argon line.

Aerology has been annexed to the field of polar exploration with interesting results. Long series of upper-air soundings were made by the recent expeditions of Scott and Filchner in the Antarctic, and by Jost and Stolberg, at Godhavn, on the west coast of Greenland, in 1912–13. The latter observers sent up 120 pilot balloons, for one of which they claim the hitherto unprecedented altitude of 39 kilometers (24.2 miles) above sea level.(**5**) They were unable to find at any altitude evidence of a regular circumpolar whirl in the atmosphere.

A timely summary of the immense body of international kite and balloon observations was prepared by Mr. E. Gold in 1912, and has recently been published as Geophysical Memoir No. 5 of the British Meteorological Office.

The application of aerology to the needs of the aeronaut has given birth to a new subbranch of science, "aeronautical meteorology." Its content is perhaps best represented and delimited in a very practical little work by Dr. Franz Linke, entitled "Aeronautische Meteorologie" (2 vols., Frankfurt a. M., 1911).

At the beginning of the year 1911 the world's first aeronautical weather bureau was organized in Germany. Observations of the air currents at various altitudes are made daily with pilot balloons at a score of stations scattered over that empire and telegraphed to the Lindenberg Observatory, whence bulletins are issued to all parts of the country for the guidance of aeronauts.

The measurement of solar radiation is still a capital problem, as it was five years ago. The most definite step in advance has been Abbot's redetermination of the solar constant (1.922 standard calories per square centimeter per minute at mean solar distance, with fluctuations to the extent of about 10 per cent). Abbot (**6**) is now endeavoring to check these results by means of observations obtained at great altitudes with sounding balloons. Much attention has recently been devoted to attempts to measure separately the kind or kinds of radiation having most influence upon plant growth and other biological processes(**7**).

In the field of dynamical meteorology, or atmospheric mechanics, a new personality has arisen, viz, Prof. V. Bjerknes, whose elaborate treatise on "Dynamic Meteorology and Hydrography" is in course of publication by the Carnegie Institution and who is also issuing a

series of memoirs from the Geophysical Institute of the University of Leipzig. Of Bjerknes's large work, Mr. Gold, the British authority on meteorological physics, says that—

it does not contain new discoveries or throw much fresh light on individual atmospheric phenomena, but it presents what is fundamental in our knowledge of the physics of the atmosphere in a new way and makes possible the application of methods which have hitherto been disregarded because of the immense labor involved in dealing with even a single case.

Renewed attention has been directed to agricultural meteorology, though the limits and aims of this subject are still rather vague. At the instance of the International Institute of Agriculture, in Rome, a commission on Agricultural Meteorology has been organized under the International Meteorological Committee. A special service of agricultural meteorology has been established in France, and one which was founded some years ago in Russia has recently attracted general notice.

In the United States the attention of agricultural meteorologists has been given chiefly to the improvement and the theory of frost protection, especially by means of "orchard heating," though there has also been much investigation of weather-crop correlations. Agriculture throughout the world suffers immense losses from hailstorms (amounting, according to one estimate, to $200,000,000 a year), and for centuries some practical means of mitigating this scourge has been eagerly sought. "Hail shooting" dates from the middle ages. This expedient gave place to the "hail rod," or *paragrêle* (imitated from the lightning rod), toward the end of the eighteenth century. In 1896 "hail shooting" was revived, and it is still practiced (with cannons, bombs, and rockets) on a vast scale; and, finally, in 1911, a new form of *paragrêle*, fantastically named the "electric Niagara," came into widespread use in France. The last-named device is nothing more than an overgrown lightning rod, and its inefficacy in averting hailstorms not only follows from scientific considerations but also appears to have been amply demonstrated by the experience of French husbandmen during the past two years. Hailstorm insurance (**8**) is growing apace in Europe (where it dates from the eighteenth century), but is a rarity in the United States.

In atmospheric electricity no such expansion in apparatus and methods has been witnessed during the past lustrum as occurred about the beginning of the century in consequence of the discoveries of Linss, Elster and Geitel, C. T. R. Wilson, Gockel, and others. Observations have been more fully standardized, but their interpretation continues to be a difficult problem. The discovery of ionization has, however, had far-reaching results; as, for example, in furnishing the basis for a plausible theory of thunderstorm electricity (**9**). The mechanism of the lightning flash has been the subject of brilliant investigations by B. Walter, of Hamburg, whose double-camera method of lightning photography was first announced in 1910 (**10**), and who has since supplemented this with a stereoscopic process.

Atmospheric optics remains a strikingly neglected branch of knowledge. Physicists, astronomers, and meteorologists, especially in English-speaking countries, continue to report their individual observations of halos, rainbows, and the like without reference to the existing body of knowledge on these subjects and in language suggesting that Bravais, Mascart, Pernter, and the other specialists in this field have lived in vain. However, the situation has recently improved. Besson's compendious account of the known forms of halo (**11**) has furnished a much-needed manual for observers of this particular group of photometeors. The remarkable halos seen in the eastern United States November 1–2, 1913, stimulated interest in halo observing in this country. Simpson's observations during Capt. Scott's last Antarctic expedition led to the interesting announcement that coronas are probably never due to ice, but always to water (or dust), thus suggesting a new means of ascertaining the constitution of clouds (**12**).

In weather forecasting undoubtedly the salient feature of recent progress has been the enlargement of the field of observation, through the establishment of new stations and the addition of wireless reports from vessels. Wireless telegraphy has also brought certain remote land stations into the telegraphic weather-reporting *réseau;* e. g., Spitzbergen, far within the Arctic circle, and the subantarctic station at Macquarie Island. During Dr. Douglas Mawson's recent sojourn in Adelie Land telegraphic weather reports were received in Australia from the Antarctic continent itself—a notable milestone in the history of science—and a similar undertaking in the far north forms part of the program of the Crocker Land expedition, now installed in Greenland. Printed daily synoptic charts have notably expanded in several cases; e. g., the Russian chart now extends from Iceland to eastern Siberia, and, since January 1, 1914, the United States Weather Bureau has published daily telegraphic weather charts that girdle the globe. European forecasters evince much confidence in the observation of pressure changes (the "barometric tendency") according to Ekholm's method, and the indications of isallobaric charts (**13**).

Dynamic meteorologists and aerologists have led a campaign in behalf of new meteorological units, especially dynamic units of atmospheric pressure on the C. G. S. system ("bars," etc.) and centigrade degrees of temperature reckoned from absolute zero (**14**). These units are now fully and officially established in aerology, and are coming into use on weather maps (e. g., the United States Weather Bureau's synoptic chart of the Northern Hemisphere).

FORTHCOMING METEOROLOGICAL MEETINGS.

On September 8–12 a conference is to be held at Edinburgh for the purpose of discussing "the various aspects of the physical sciences in their application to the study of weather." The special occasion of such a meeting is that the British Association holds its sessions this year in Australia, and will be attended by comparatively few persons from the mother country. The scope of the papers to be read at the Edinburgh conference will, it is hoped, include the physical and observational aspects of meteorology, climatology, medico-climatology oceanography, limnology, atmospheric electricity, terrestrial magnetism, and seismology. Sir John Murray, the eminent oceanographer and marine biologist, who died the middle of March, was to have presided over the meeting, while the honorary secretary of the organizing committee is Mr. F. J. W. Whipple, Meteorological Office, South Kensington, London. The membership fee is 10 shillings. During the same month (September, 1914) an international meteorological congress is to be held at Venice, under the auspices of the Italian Meteorological Society. It will include five sections, viz, climatology,

agricultural meteorology, aerology, marine meteorology, and pure meteorology. The subscription to the congress is 10 lire, and applications are to be addressed to the general secretary, Rev. Emilio Hoenning O'Carroll, director of the Patriarchal Observatory, Venice. It should be noted that this congress will not be one of the official assemblies of meteorologists pertaining to what is known as the "International Meteorological Organization." These official assemblies are now held triennially, and are either meetings of the International Meteorological Committee (e. g., the one held in Rome last year) or International Meteorological Conferences (comprising the directors of all official weather services). No meeting of this series has been designated a "congress" since that held in Rome in 1879. The coming meeting in Venice will, however, be analogous to the unofficial congresses held in Chicago, in 1893, and in Paris, in 1900.

UPPER-AIR RESEARCH IN INDIA.

The Government of India has sanctioned a scheme of upper-air observation, to extend over 10 years, and to cost about $100,000. The headquarters are to be at Agra, where an observatory is building, and where it is proposed to send up sounding-balloons twice a week to the greatest heights attainable. There will also be four or five auxiliary stations, at which instruments will be sent up to moderate altitudes (2 or 3 miles), especially to obtain information of value to the forecasters. Mr. J. H. Field will be in charge of this work.

REFERENCES AND NOTES.

(**1**) The "record" low temperature heretofore measured anywhere in the atmosphere is – 91.9° C. (–133.4° F.), observed above Batavia Nov. 5, 1913. In this case the clockwork of the meteorograph failed to work; hence the altitude at which the minimum temperature prevailed is uncertain.

(**2**) Wegener's fullest presentation of these views will be found in his "Thermodynamik der Atmosphäre," Leipzig, 1911.

(**3**) Arb. K. Preuss. Aeron. Obs. Lindenberg, **7**, 1911, p. 236.

(**4**) Phys. Zeit., **14**, 1913, p. 677 ffg.

(**5**) A. de Quervain, "Quer durchs Grönlandeis," München, 1914, p. 175. The previous "record" for any aeronautical device was 35,080 meters (21.8 miles) attained by a sounding balloon sent up from Pavia, Italy, Dec. 7, 1912. The American "record" is 32,643 meters, at Avalon, Cal., July 30, 1913.

(**6**) Journ. Wash. Acad. Sci., **4**, 1914, p. 109.

(**7**) The literature is voluminous and not yet summarized. See, as examples, the record of C. Dorno's suggestive observations in his "Studie über Licht und Luft des Hochgebirges" (Braunschweig, 1911), or the abstract of H. A. Spoehr's researches in Yearbook Carnegie Inst., 1913, p. 83-84.

(**8**) In Germany alone insurance of this class amounted to $825,000,000 in 1911.

(**9**) G. C. Simpson, in Proc. Roy. Soc. Lond., A, **82**, 190, p. 169-172, and Mem. Indian Met. Dept., **20**, 1910, p. 141-332.

(**10**) Jahrb. Hamb. Wiss. Anstalten, **27**, 1909, 5. Beiheft, Hamburg, 1910.

(**11**) L. Besson, "Les différentes formes de halos et leur observation." Bull. Soc. Astr. France, March-May, 1911; also published separately.

(**12**) Q. J. Roy. Met. Soc., **38**, 1912, p. 291 ffg.

(**13**) See a résumé of this subject in W. N. Shaw's "Forecasting Weather," London, 1911, p. 337 ffg.

(**14**) The most comprehensive presentation of this subject is that given in the "Observer's Handbook" of the British Meteorological Office for 1913, p. ix ffg.

SECTION VI—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

By P. C. DAY, Climatologist and Chief of Division.

Pressure.—The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

In marked contrast to the average pressure for January, 1914, that for February was above the normal for the entire country, although it was near the normal in the Pacific coast States, as well as in the Middle and South Atlantic and east Gulf States and the peninsula of Florida. The most pronounced plus departures occurred in the northern Rocky Mountain region, northern Plain States, the Missouri and upper Mississippi Valleys, and the Lake region.

During the first week comparatively low pressure obtained over practically all sections east of the Rocky Mountains, while the week beginning with the 7th was characterized by comparatively high pressure over these districts, especially over the Lake region and New England on the 11th–13th, where unusually high pressure and extremely low temperatures prevailed. From the 13th to 17th the middle and northern portions of the Plateau districts and Rocky Mountain region had abnormally high pressure, while at the same time an area of marked low pressure and high, shifting gales passed northeastward along the Atlantic coast. High pressure again obtained over the eastern districts from the 24th to the 27th, but the month closed with a barometric depression moving eastward over the Lake region and a second storm on the east Gulf coast.

The distribution of the highs and lows was generally favorable for northerly and northwesterly winds over most of the country during the greater portion of the month, and these directions were the prevailing winds over practically all districts east of the 100th meridian.

Temperature.—The month opened with moderate temperatures for the season prevailing over practically the entire country, but by the morning of the 3d a decided cold wave was advancing from the British Northwest and northern Rocky Mountain districts, with temperature readings from 20° to 30° below zero in North Dakota and Montana. This cold wave advanced rapidly southeastward and by the end of the first week the line of freezing temperature extended as far south as the middle and west Gulf coast, while zero weather was general throughout the Missouri Valley and Plains States.

For the first week of the month the temperature averaged above the normal generally, except in the Missouri Valley and the central and northern portions of the Rocky Mountain and Plateau regions, where the weather was colder than normal. The negative departures for this period were marked in the northern border States, especially in Montana, where the average for the week was 20° or more below the normal. Over the southern, central, and eastern districts the average was well above the normal, especially in portions of New England.

At the beginning of the second decade low temperatures and wintry weather again overspread the northern Rocky Mountain districts, and moved thence during the next few days eastward over the Lake region and down the St. Lawrence Valley. Very low temperatures were experienced over the extreme northern districts during the passage of this cold wave, especially in portions of New England, where the lowest temperature recorded in many years occurred. However, the cold wave was confined principally to the more northern sections and only moderately cold weather occurred in the southern districts.

During the following several days temperatures remained comparatively low over most sections but no important changes occurred. For the 10-day period from the 7th to the 16th, the temperature averaged below the normal for all sections east of the Rocky Mountains, save in the Florida Peninsula, the negative departures being especially marked in New England, the Lake region, and the upper Mississippi Valley.

From the 22d to the 26th a cold wave again overspread the country east of the Rocky Mountains and freezing temperatures extended as far south as the Gulf coast and northern Florida. However, the weather rapidly moderated and the month closed with temperatures above the seasonal averages over much of the country.

After the first week the temperatures averaged below the normal generally east of the Rocky Mountains, but the weather was comparatively warm during the entire month in all districts to the westward. No unusually high temperatures occurred during the month, but on the morning of the 12th over New England and portions of New York the minimum temperatures were as low as had been recorded in February for many years; in fact, at points in Maine the lowest temperatures for at least 40 years were experienced.

Temperatures below freezing occurred in all parts of the country, save over the peninsula of Florida, extreme southern Texas, southwestern Arizona, and at the lower elevations of California. No damaging frosts were reported from the last-named State.

For the month as a whole the temperature averaged below the normal over all districts from the Rocky

Mountains eastward, the negative departures being pronounced in the central and northern districts, especially in the Lake region and New England, while to the westward of the Rocky Mountains the average was above the normal, with greatest departures in southern California and along the north Pacific coast.

Precipitation.—The geographical distribution of the precipitation during the month is illustrated on Chart V. The amounts were quite well distributed over the eastern sections of the country, with some local heavy falls in the east Gulf and South Atlantic States, although there was a deficiency of about 1 inch in large portions of Texas, and the east Gulf States, as well as in New England and the Lake region.

The precipitation was likewise quite generally below the average in the Plains region and over the mountain districts of the West, except those of California. Heavy falls occurred in southern California, resulting in damaging floods in some districts. Except for the heavy falls noted in portions of California, the east Gulf and South Atlantic States, the rainfall was not excessive in any portion of the country to any noteworthy extent. There were moderate excesses above the normal over considerable portions of the South Atlantic and Gulf States, the Ohio, middle Mississippi, and lower Missouri valleys, and the northern and southern portions of the Rocky Mountain region.

Snowfall.—More than the average amount of snow occurred in New England, New York, and portions of the adjoining States, and from Kansas and Nebraska eastward to the Ohio Valley. Unusually heavy falls occurred in the interior of the east Gulf and South Atlantic States on the 25th and 26th. The fall in the mountains of California was likewise heavy.

Over all northern districts from the Lake region westward and throughout the mountain regions of the West, except in California, the snowfall was very generally less than the average, and at the end of the month there was practically none on the ground at the lower levels, and the supply stored in the mountains had increased but little, if any, over that reported at the end of last month.

GENERAL SUMMARY.

The month as a whole was one of moderate winter conditions and not unfavorable, except in a few minor particulars. However, temperature conditions were in marked contrast to those of the preceding two months. January was exceptionally warm for the season of the year over the entire country, while December was likewise warm over all eastern districts. The change from these abnormally warm to much colder conditions during February was favorable in that it retarded or prevented premature plant or fruit development and lessened the danger of later damage from frost. No damaging frosts occurred during the month in the citrus fruit or winter vegetable-growing districts, and the winter-wheat belt was largely covered with snow during the period when cold weather would have seriously injured the growing plants. At the end of the month the snow had largely disappeared, except over the North Atlantic States and in the Lake region.

Several periods of cold weather caused the formation of considerable ice on the streams and other bodies of water in the central and northern portions of the country, and in New England and other sections where ice is gathered for commercial purposes the supply was abundant.

Average accumulated departures for February, 1914.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since January 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since January 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F	°F	°F	Inch.	Inch.	Inch.			P. ct.	P. ct.
New England	19.8	−5.9	−6.0	2.61	−0.70	−1.00	4.9	−0.4	71	− 4
Middle Atlantic	27.7	−4.9	−1.5	3.07	−0.10	−0.10	5.3	−0.2	70	− 4
South Atlantic	45.2	−2.6	+1.1	5.02	+1.10	−0.40	5.7	+0.4	74	− 2
Florida Peninsula	65.9	−0.9	−1.1	1.87	−0.70	+0.20	5.2	+0.9	80	0
East Gulf	48.1	−2.8	+0.3	5.24	+0.50	+1.40	5.7	+0.1	74	− 2
West Gulf	47.2	−2.4	+3.9	2.32	−0.40	−2.60	5.9	+0.3	74	0
Ohio Valley and Tennessee	30.3	−5.4	−0.2	3.65	+0.10	−1.50	5.8	−0.4	7[illegible]	+ 2
Lower Lakes	17.1	−7.6	−4.2	1.68	−0.80	−0.80	5.8	−1.0	76	− 4
Upper Lakes	11.8	−7.4	−1.3	1.04	−0.70	−0.30	5.9	−0.4	79	− 3
North Dakota	1.4	−5.5	+4.3	0.30	−0.20	−0.20	5.2	+0.2	83	+ 3
Upper Mississippi Valley	18.9	−5.7	+3.7	1.60	−0.10	−0.60	5.5	+0.3	80	+ 3
Missouri Valley	20.9	−3.6	+7.1	1.69	+0.40	−0.20	5.5	+0.3	77	+ 2
Northern slope	19.9	−1.6	+7.7	0.95	+0.20	−0.20	6.0	+0.9	75	+ 4
Middle slope	31.4	−1.0	+9.1	0.75	0.00	−0.60	4.1	−0.3	69	+ 2
Southern slope	44.6	+0.1	+8.4	0.31	−0.80	−1.70	4.6	−0.2	57	−11
Southern Plateau	44.6	−0.2	+3.2	0.50	−0.20	−0.50	3.2	−0.4	51	+ 7
Middle Plateau	33.6	+1.1	+5.8	0.84	−0.30	+1.10	4.4	−0.7	66	+ 2
Northern Plateau	32.7	+0.6	+9.2	1.22	−0.20	+0.30	7.8	+1.6	75	0
North Pacific	42.9	+2.3	+6.3	3.43	−2.10	+3.80	7.5	+0.4	84	+ 3
Middle Pacific	50.5	+1.5	+3.0	4.22	−0.10	+3.40	4.8	−0.8	75	− 1
South Pacific	56.1	+3.5	+6.5	3.39	+0.90	+6.60	4.6	+0.3	71	+ 2

Maximum wind velocities during February, 1914.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi/hr				Mi/hr	
Abilene, Tex	22	50	w.	Mount Weather, Va.	14	70	nw.
Bismarck, N. Dak.	28	54	nw.	Do	16	62	nw.
Block Island, R. I.	7	50	w.	Nantucket, Mass	6	51	se.
Do	8	60	w.	Do	14	59	se.
Do	9	60	w.	Do	16	59	n.
Do	11	64	nw.	Do	20	53	ne.
Do	12	58	nw.	New York, N. Y	7	60	w.
Do	14	72	e.	Do	9	51	nw.
Do	15	50	w.	Do	12	56	nw.
Do	16	72	nw.	Do	14	75	nw.
Do	17	59	w.	Do	16	52	nw.
Do	21	50	ne.	Norfolk, Va	16	55	nw.
Buffalo, N. Y	1	72	w.	North Head, Wash.	1	50	n.
Do	7	88	sw.	Do	21	50	sw.
Do	8	72	w.	Do	23	65	se.
Do	9	50	w.	Do	26	62	se.
Burlington, Vt	3	50	s.	Do	28	62	se.
Do	22	54	s.	Oklahoma, Okla	22	56	nw.
Canton, N. Y	1	64	w.	Pensacola, Fla	6	60	se.
Do	7	58	w.	Pittsburgh, Pa	7	50	w.
Columbus, Ohio	8	52	nw.	Point Reyes Light, Cal	4	64	nw.
Eastport, Me	14	66	ne.	Do	5	57	nw.
Hatteras, N. C	13	50	se.	Do	18	54	s.
Do	20	68	n.	Do	19	54	s.
Do	24	56	n.	Do	20	80	s.
Huron, S. Dak	28	54	nw.	Providence, R. I	8	50	nw.
Jacksonville, Fla	13	54	sw.	Do	14	56	nw.
Kansas City, Mo	28	53	nw.	Do	16	50	nw.
Lincoln, Nebr	28	56	nw.	St. Louis, Mo	28	60	nw.
Mount Tamalpais, Cal	4	62	nw.	St. Paul, Minn	28	52	nw.
Do	5	64	nw.	Sioux City, Iowa	28	68	nw.
Do	18	56	sw.	Tatoosh Island, Wash	14	52	e.
Do	19	50	sw.	Do	26	58	s.
Do	20	56	se.	Do	28	62	s.
Do	22	50	sw.	Do			
Mount Weather, Va.	7	56	nw.	Toledo, Ohio	7	56	sw.

MEAN LAKE LEVELS DURING FEBRUARY, 1914.

The United States Lake Survey reports the stages of the Great Lakes for the month of February, 1914, as follows:

Lakes.	Feet above mean sea level.
Superior	602.18
Michigan-Huron	580.06
Erie	571.73
Ontario	245.87

Lake Superior is 0.20 foot lower than last month, 0.61 foot higher than a year ago, 0.38 foot above the average stage of February of the last 10 years, 0.30 foot below the high stage of February, 1901, and 1.42 feet above the low stage of February, 1871. It will probably fall 0.1 foot during March.

Lakes Michigan and Huron are 0.03 foot lower than last month, 0.11 foot higher than a year ago, 0.01 foot lower than the average stage of February of the last 10 years, 2.66 feet below the high stage of February, 1886, 0.90 foot above the low stage of February, 1896. They will probably rise 0.1 foot during March.

Lake Erie is 0.33 foot lower than last month, 0.68 foot lower than a year ago, 0.08 foot above the average stage of February of the last 10 years, 2.02 feet below the high stage of February, 1863, and 1.10 feet above the low stage of February, 1902. It will probably rise 0.1 foot during March.

Lake Ontario is 0.27 foot higher than last month, 0.88 foot lower than a year ago, 0.19 foot higher than the average stage of February of the last 10 years, 1.80 feet below the high stage of February, 1886, and 2.04 feet above the low stage of February, 1897. It will probably rise 0.2 foot during March.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least precipitation, and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Temperature and precipitation by sections, February, 1914.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	46.1	−0.6	Thomasville	82	23	Riverton	13	8	4.21	−1.75	Daphne	7.80	Benton	2.59
Arizona	46.9	+0.3	Gila Bend	84	20	2 stations	− 4	2	1.10	−0.12	Thomas	5.79	St. Michaels	T.
Arkansas	40.4	−1.1	Portland	79	3	Swain	− 2	7	4.23	+0.57	Dumas	8.60	Pond	1.68
California	48.4	−0.1	Healdsburg	87	13	Bridgeport	−19	2	5.49	+1.08	Mono Ranch	19.35	Bagdad	0.00
Colorado	25.0	−1.3	Lamar	75	22	Lay	−37	6	0.74	−0.48	Ironton	3.90	Blanca	0.00
Florida	59.5	−0.2	Davie	89	7	3 stations	28	26†	4.82	+1.49	Wausau	12.51	Fort Myers	0.50
Georgia	45.9	−1.5	Quitman	80	3	2 stations	15	26	5.29	0.00	Waycross	12.89	Newnan	2.27
Hawaii [for January]	67.0	......	Olaa Mill	89	3	Volcano House	43	8	7.66	......	Waiakamoi	28.93	Waipahu	1.41
Idaho	28.8	+0.3	Garnet	64	28	Irwin	−43	6	1.61	−0.11	Musselshell	4.80	Challis	0.10
Illinois	21.8	−4.8	Mascoutah	64	17	2 stations	−20	9	2.38	+0.47	Golconda	7.23	2 stations	0.39
Indiana	22.8	−5.9	Rome	60	22	Laporte	−16	9	3.07	+0.12	Huntingburg	6.03	Cambridge City	0.53
Iowa	16.8	−3.7	Pella	59	28	Inwood	−29	7	0.87	−0.28	Keosauqua	1.99	Britt	0.32
Kansas	30.2	−0.7	Coolidge	79	21	Goodland	−13	6	1.24	+0.11	Chanute	5.03	2 stations	T.
Kentucky	32.2	−3.2	Franklin	69	6	Williamstown	− 2	24	4.14	+0.40	Louisville [1]	6.50	Pikeville	2.36
Louisiana	50.2	−2.0	Sugartown	88	18	Grand Cane	8	7†	5.25	+0.47	Donaldsonville	11.60	Lake Charles	2.47
Maryland and Del	28.7	−3.0	Yarrow	68	1	Oakland	−28	25	2.78	−0.31	Deer Park	4.23	Chewsville	1.78
Michigan	12.6	−6.4	2 stations	50	21	Bergland	−47	12	1.10	−0.73	Benzonia	3.13	Owosso	0.17
Minnesota	2.8	−6.9	Fairmont	57	28	Roseau	−52	11	0.44	−0.22	Glencoe	1.51	Warren	T.
Mississippi	46.4	−1.0	Leakesville	81	6	Austin	13	8	4.49	−0.74	Pearlington	9.33	Grenada	2.10
Missouri	28.3	−3.2	Cardwell	75	26	2 stations	−11	7†	2.71	+0.42	Caruthersville	4.98	Grant City	0.80
Montana	19.5	−0.9	Busteed	61	16	Bowen	−54	6	0.84	+0.13	Heron	3.39	Bridger	T.
Nebraska	22.1	−2.1	Hillside	78	21	Burge	−31	7	0.65	−0.06	2 stations	1.75	Ashton	0.06
Nevada	35.5	+2.4	Logan	79	22	Tecoma	−16	6	0.87	−0.39	Marlette Lake	3.26	Beowawe	T.
New England	16.8	−5.6	Bridgeport, Conn	57	4	Presque Isle, Me	−36	11	2.48	−1.09	Westboro, Mass	4.94	Burlington, Vt	0.41
New Jersey	25.5	−4.5	Indian Mills	67	4	Culvers Lake	−17	12	2.85	−1.03	Lakewood	4.94	Culvers Lake	1.89
New Mexico	37.1	+0.2	Carlsbad	82	21	Dulce	−21	2†	0.31	−0.47	Tajique (near)	1.72	7 stations	0.00
New York	14.8	−6.3	Oyster Bay	59	4	Nehasane	−43	13	2.17	−0.48	Spier Falls	4.67	Chazy	0.05
North Carolina	39.1	−2.1	Swan Quarter	76	4	2 stations	6	17†	4.31	−0.07	Southport	8.56	Hot Springs	1.08
North Dakota	1.1	−6.4	New England	57	28	.....do	−47	11	0.32	−0.18	Ranger	1.03	3 stations	0.00
Ohio	22.1	−5.3	Ironton	67	22	Garrettsville	−24	25	3.04	+0.18	Portsmouth	5.27	Wauseon	0.98
Oklahoma	37.8	−1.0	2 stations	79	20	Rankin	− 9	6	0.96	−0.22	Idabel	3.21	3 stations	T.
Oregon	37.8	+1.1	Pilot Rock	75	8	Austin	−21	6	3.06	−0.97	Deadwood	14.70	Diamond	0.12
Pennsylvania	21.8	−5.2	Warren	65	4	Saegerstown	−27	25	2.78	−0.19	Somerset	6.20	Montrose	1.30
Porto Rico	73.4	+0.2	Humacao	93	11	Cayey	49	27	4.45	+1.93	Rio Grande [2]	12.60	Ponce	1.92
South Carolina	44.6	−2.2	3 stations	78	3†	Darlington	14	27	4.40	−0.11	Beaufort	9.49	St. Matthews	2.90
South Dakota	11.8	−5.1	Fort Meade	66	17	Bellefourche	−42	7	0.87	+0.24	Sorum	2.66	Eureka	0.05
Tennessee	38.6	−0.8	2 stations	72	6	Mountain City	0	17	3.68	−0.86	Perryville	5.61	Nashville	2.03
Texas	48.3	−1.5	Fort McIntosh	98	6	2 stations	− 5	6	1.53	−0.47	Hempstead	6.08	14 stations	0.00
Utah	29.6	−0.7	Mount Home	70	18	Woodruff	−22	6	0.98	−0.37	Park City	2.55	Low	0.00
Virginia	32.8	−3.1	2 stations	69	3	3 stations	− 6	17	3.21	−0.27	Rocky Mount	4.88	Culpeper	1.76
Washington	35.2	+0.6	.....do	68	20	Newport	−25	5	2.83	−1.07	Yale	11.45	Fort Simcoe	0.05
West Virginia	28.4	−3.3	Bancroft	70	3	2 stations	−22	25	3.64	+0.49	Pickens	6.96	Moundsville	1.63
Wisconsin	9.1	−6.6	Shullsburg	49	27	Long Lake	−42	12	0.65	−0.50	Sheboygan No. 2	1.90	Vudesare	0.18
Wyoming	21.0	+0.8	Upton	77	22	Grand Canyon, Y. N. P.	−53	6	0.74	−0.24	Bechler River, Y. N. P.	3.16	2 stations	0.00

† Other dates also. [1] Cherokee Park. [2] El Verde.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., seventy-fifth meridian time daily, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values, except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., seventy-fifth meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart V.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VI.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observations, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction $t_0 - t$, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given.

Chart VIII.—Depth of snow on ground at end of the month, expressed in inches and tenths.

Charts VII and VIII are published only when the general snow cover is sufficiently extensive to justify their preparation.

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1914.*

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure in inches: Station reduced to mean of 24 hours.	Pressure in inches: Sea level, reduced to mean of 24 hours.	Pressure in inches: Departure from normal.	Temperature: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
New England.							**19.8**	**- 5.9**										**71**	**2.61**	**- 0.7**										**4.9**		
Eastport	76	67	85	29.95	30.04	+0.06	14.8	- 6.6	43	7	24	-23	12	6	35	13	10	78	2.26	- 1.4	10	10,391	w.	66	ne.	14	16	6	6	4.8	16.8	0.2
Greenville	1,070	6	....	28.82	30.06	......	5.9	......	47	28	17	-29	12	-5	37	....	....	....	1.92	......	7	......	se.	....	....	....	....	....	....	....	19.2	38.0
Portland, Me	103	82	117	29.97	30.10	+.08	17.2	- 6.6	50	4	26	-17	12	9	27	15	7	65	3.92	+ 0.3	6	7,131	n.	42	n.	14	17	4	7	3.8	19.7	11.0
Concord	288	70	79	29.79	30.13	+.09	15.6	- 8.0	47	4	26	-18	16	5	43	....	....	....	1.65	- 1.6	6	4,589	nw.	30	w.	1	14	7	7	4.4	17.6	18.0
Burlington	404	11	48	29.68	30.16	+.13	10.2	- 7.7	45	28	19	-22	12	1	29	....	....	....	0.41	- 1.0	3	8,508	n.	54	s.	22	9	12	7	5.1	6.9	3.2
Northfield	876	12	60	29.13	30.14	+.10	7.7	- 9.5	47	28	20	-33	24	-5	50	5	3	86	1.56	- 0.7	7	5,438	n.	36	sw.	7	11	7	10	5.0	19.7	20.8
Boston	125	115	188	29.96	30.10	+.06	24.3	- 3.7	56	4	32	-11	12	17	26	21	13	64	3.07	- 0.4	8	8,553	w.	44	e.	14	11	10	7	4.3	20.6	5.6
Nantucket	12	14	90	30.06	30.07	+.03	28.2	- 4.4	50	7	35	- 4	12	22	22	26	21	76	4.00	+ 0.9	10	13,124	w.	59	se.	14	10	7	11	5.8	19.2	T.
Block Island	26	11	46	30.07	30.10	+.04	26.2	- 5.0	48	7	32	- 4	12	20	26	24	20	77	2.39	- 1.9	8	16,407	w.	72	nw.	16	9	7	12	6.0	8.9	0.5
Narragansett	....	9	....	......	......	......	25.0	- 3.3	56	4	34	- 8	12	16	30	....	....	....	3.56	......	8	......	nw.	....	....	....	16	5	7	....	18.7	1.8
Providence	160	215	251	29.93	30.11	+.06	23.4	- 5.6	55	4	31	- 9	12	15	27	20	14	68	2.99	- 1.4	8	10,954	nw.	56	nw.	14	12	8	8	4.8	20.4	5.0
Hartford	159	122	140	29.95	30.14	+.08	21.2	- 6.0	51	4	30	-10	12	13	32	18	10	65	2.79	- 0.8	8	5,822	n.	37	nw.	14	10	6	12	5.4	27.8	9.0
New Haven	106	117	155	30.01	30.14	+.07	23.6	- 4.7	55	4	32	- 7	12	15	32	20	10	58	3.68	- 0.1	11	7,623	n.	42	nw.	14	10	9	9	5.0	20.3	5.8
Middle Atlantic States.							**27.7**	**- 4.9**										**70**	**3.07**	**- 0.1**										**5.3**		
Albany	97	102	115	30.06	30.17	+.10	15.7	- 7.9	45	28	25	-16	12	6	38	13	7	69	1.85	- 0.7	6	6,016	n.	27	s.	3	12	9	7	4.6	26.1	8.8
Binghamton	871	10	69	29.18	30.16	+.08	16.0	- 8.7	48	28	26	-15	25	6	46	....	....	....	2.44	+ 0.5	9	4,576	nw.	26	sw.	7	9	5	14	6.1	26.3	5.8
New York	314	414	454	29.78	30.14	+.06	25.3	- 5.4	52	4	33	- 2	12	18	30	21	12	57	3.27	- 0.5	10	13,239	nw.	75	nw.	14	10	8	10	5.5	14.1	2.0
Harrisburg	374	94	104	29.76	30.18	+.09	24.0	- 5.9	47	1	31	0	26	17	34	21	15	70	3.51	+ 0.8	12	5,559	w.	33	w.	8	10	4	14	5.7	25.5	3.0
Philadelphia	117	123	184	30.02	30.16	+.06	29.0	- 3.8	56	3	36	3	13	22	28	25	20	70	3.32	- 0.1	11	7,938	nw.	39	nw.	14	12	7	9	4.9	15.7	1.5
Reading	325	81	98	29.80	30.17	......	24.8	......	49	4	32	0	13	18	37	22	16	70	3.27	......	11	5,724	nw.	33	w.	7	10	5	13	5.8	19.7	4.0
Scranton	805	111	119	29.26	30.17	+.09	19.8	- 7.1	51	27	29	- 8	12	11	37	18	14	79	5.23	+ 2.5	10	5,419	nw.	42	sw.	7	6	15	7	5.6	27.9	4.3
Atlantic City	52	37	48	30.09	30.15	+.04	30.2	- 2.8	57	4	38	3	25	23	30	26	20	69	2.67	- 0.6	11	6,664	nw.	29	e.	14	10	9	9	5.3	9.9	....
Cape May	17	13	49	30.14	30.16	+.05	31.5	- 2.6	56	4	38	5	25	24	28	28	24	80	2.50	- 0.8	10	7,341	n.	36	nw.	14	10	10	8	5.2	11.6	0.5
Trenton	190	159	183	29.92	30.14	......	25.6	......	53	4	33	- 1	13	18	34	22	16	70	3.00	- 0.2	11	9,461	w.	48	ne.	14	12	5	11	5.1	17.1	3.6
Baltimore	123	100	113	30.04	30.18	+.07	30.2	- 4.4	57	4	37	8	25	23	27	26	19	67	2.89	- 0.6	8	5,555	n.	29	w.	7	12	6	10	4.9	11.4	0.5
Washington	112	62	85	30.04	30.16	+.05	30.1	- 4.4	59	3	38	- 1	25	22	34	25	18	66	3.05	- 0.4	9	5,821	n.	40	nw.	16	11	8	9	5.0	9.3	T.
Lynchburg	681	83	88	29.38	30.15	+.04	35.2	- 3.0	64	4	45	9	25	26	34	29	23	67	2.77	- 0.7	12	5,089	sw.	27	w.	7	9	11	8	5.3	11.0	....
Mount Weather	1,725	10	75	28.22	30.14	+.03	24.6	- 4.5	53	3	33	- 1	24	17	29	21	14	70	1.99	- 1.2	9	12,716	nw.	70	nw.	14	8	9	11	5.7	13.5	3.5
Norfolk	91	170	205	30.06	30.16	+.05	38.6	- 3.2	65	18	47	15	25	30	35	34	28	70	3.67	- 0.1	12	10,868	sw.	55	nw.	16	10	9	9	5.6	7.7	....
Richmond	144	11	52	30.01	30.18	+.07	35.0	- 4.9	64	3	44	8	25	26	34	29	23	69	3.27	+ 0.2	12	6,227	s.	34	nw.	16	10	8	10	5.1	10.8	T.
Wytheville	2,293	40	47	27.68	30.16	+.04	30.5	- 4.6	60	3	40	5	15	21	34	27	23	79	3.75	- 0.3	14	4,179	w.	30	w.	7	14	4	10	5.0	18.5	T.
South Atlantic States.							**45.2**	**- 2.6**										**74**	**5.02**	**+ 1.1**										**5.7**		
Asheville	2,255	70	84	27.72	30.17	+.04	36.9	- 1.6	63	19	46	15	8	28	42	32	27	74	2.24	- 2.4	11	6,792	nw.	36	e.	6	11	7	10	5.2	4.9	....
Charlotte	773	68	76	29.29	30.15	+.03	39.6	- 4.5	67	4	48	17	13	31	28	34	28	70	4.03	- 0.4	14	5,425	ne.	28	nw.	16	12	4	12	5.5	8.1	T.
Hatteras	11	12	50	30.10	30.11	.00	45.8	- 0.8	68	3	53	27	25	39	23	42	39	82	4.32	- 0.2	12	12,382	n.	68	n.	20	6	11	11	6.2	T.	....
Manteo	12	12	46	......	......	......	42.5	......	71	7	52	21	16	33	....	....	....	....	5.48	+ 1.2	7	......	ne.	....	....	....	11	5	12	....	T.	....
Raleigh	376	103	110	29.74	30.16	+.05	38.7	- 4.6	67	3	48	15	25	30	32	32	25	62	4.45	+ 0.1	12	6,187	ne.	36	nw.	16	13	4	11	5.1	10.4	....
Wilmington	78	81	91	30.06	30.15	+.05	44.8	- 2.9	74	19	54	19	25	36	31	39	34	73	6.04	+ 2.6	9	5,946	n.	38	nw.	16	9	10	9	5.6	0.3	....
Charleston	48	11	92	30.08	30.14	+.04	48.6	- 3.1	69	19	56	26	25	41	29	44	40	78	6.87	+ 3.5	8	7,695	n.	39	ne.	13	7	11	10	5.7	2.1	....
Columbia, S. C	351	41	57	29.76	30.15	+.04	45.0	- 2.8	72	4	55	21	25	35	32	39	32	69	4.45	- 0.1	10	5,089	ne.	27	nw.	16	9	8	11	5.4	11.7	T.
Augusta	180	89	97	29.95	30.15	+.03	46.6	- 2.4	71	5	57	21	25	37	31	40	35	74	4.50	+ 0.1	12	4,535	nw.	28	w.	16	8	7	13	6.2	10.5	T.
Savannah	65	150	194	30.07	30.14	+.02	50.3	- 2.2	76	19	59	26	26	42	28	45	41	78	8.32	+ 5.0	9	8,064	nw.	40	nw.	28	8	6	14	6.1	0.5	....
Jacksonville	43	96	129	30.08	30.13	+.01	55.3	- 1.6	74	19	64	32	26	47	27	50	46	78	4.55	+ 1.1	8	6,653	ne.	54	sw.	13	9	8	11	5.6	....	....
Florida Peninsula.							**65.9**	**- 0.9**										**80**	**1.87**	**- 0.7**										**5.2**		
Key West	22	10	64	30.05	30.07	.00	69.9	- 0.9	82	13	75	57	27	65	18	65	62	81	0.96	- 0.7	7	7,601	ne.	42	w.	20	12	12	4	4.5		
Miami	25	37	72	30.07	30.10	......	67.4	- 1.4	82	14	75	43	27	60	31	62	60	80	1.21	- 1.5	7	6,639	ne.	30	ne.	9	7	9	12	6.2		
Sand Key	23	39	72	30.03	30.06	-.01	69.5	......	79	7	73	58	22	66	12	65	63	80	1.11	......	7	10,716	n.	47	nw.	28	12	13	3	4.1		
Tampa	35	79	96	30.08	30.12	+.02	60.5	- 0.4	78	19	69	41	27	52	26	55	52	81	3.43	+ 0.2	7	5,612	ne.	29	se.	20	7	9	12	6.2		
Titusville	44	6	....	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	....	....	....	....	....	....	....	....		
East Gulf States.							**48.1**	**- 2.8**										**74**	**5.24**	**+ 0.5**										**5.7**		
Atlanta	1,174	190	216	28.88	30.15	+.03	43.1	- 2.1	68	23	52	19	8	34	35	38	33	71	3.34	- 1.3	11	8,242	w.	40	nw.	24	11	6	11	5.2	3.1	....
Macon	370	78	87	29.74	30.15	+.03	46.5	- 2.4	69	23	56	21	26	36	33	41	37	78	3.99	- 0.6	9	4,627	nw.	24	nw.	16	10	6	12	5.9	6.9	....
Thomasville	273	8	57	29.84	30.14	+.02	51.4	- 3.6	77	4	62	28	26	41	38	45	42	81	12.12	+ 7.6	11	4,140	nw.	32	sw.	6	10	5	13	5.9	....	....
Pensacola	56	140	182	30.08	30.14	+.03	52.7	- 2.8	72	23	60	32	8	45	27	47	43	75	4.85	+ 0.4	8	9,068	nw.	60	se.	6	7	10	11	6.3	....	....
Anniston	741	9	57	......	......	......	43.8	- 2.0	72	23	54	20	8	34	37	....	....	....	3.53	- 1.1	11	4,702	nw.	34	se.	13	12	7	9	....	4.8	....
Birmingham	700	11	48	29.39	30.18	+.06	44.4	- 3.9	72	23	54	20	8	34	41	39	33	70	2.66	- 2.1	10	5,361	n.	28	w.	23	9	9	10	5.2	4.2	....
Mobile	57	125	161	30.08	30.14	+.03	52.0	- 1.2	78	6	61	31	8	43	28	46	41	72	7.59	+ 2.2	11	7,265	nw.	34	nw.	24	10	12	6	5.0	T.	....
Montgomery	223	100	112	29.91	30.17	+.05	48.0	- 3.3	75	23	58	24	26	38	37	42	37	72	3.29	- 2.2	9	5,034	nw.	29	w.	23	9	8	11	5.3	4.1	....
Meridian	375	85	93	29.75	30.16	+.05	46.2	- 2.9	72	23	56	23	8	36	42	41	37	76	3.48	- 1.4	11	4,199	nw.	27	w.	23	8	4	16	6.6	3.7	....
Vicksburg	247	62	74	29.89	30.18	+.08	47.6	- 3.3	73	3	57	22	7	38	39	42	36	69	6.41	+ 1.8	11	5,273	se.	29	nw.	6	9	6	13	5.8	0.2	....
New Orleans	51	90	121	30.09	30.14	+.05	53.2	- 3.1	79	6	62	31	26	44	30	48	44	76	6.43	+ 2.0	9	6,453	ne.	30	ne.	28	11	7	10	5.5	T.	....
West Gulf States.							**47.2**	**- 2.4**										**74**	**2.32**	**- 0.4**										**5.9**		
Shreveport	249	77	93	29.89	30.17	+.08	46.4	- 3.6	74	3	56	17	7	37	48	41	37	76	4.85	+ 1.2	11	5,380	se.	33	nw.	6	10	7	11	5.6	....	....
Bentonville	1,303	11	44	28.72	30.13	+.03	35.4	- 3.1	64	17	46	0	7	25	37	....	....	....	2.54	0.0	11	4,114	s.	28	s.	22	12	6	10	5.0	2.3	....
Fort Smith	457	79	94	29.65	30.14	+.04	40.1	- 1.7	69	17	50	6	7	30	32	35	31	73	2.21	- 0.5	8	6,760	e.	42	nw.	23	10	2	16	6.0	T.	....
Little Rock	357	139	147	29.78	30.17	+.06	41.8	- 2.3	68	17	51	10	7	32	35	36	29	67	2.85	- 1.3	11	6,722	s.	35	w.	22	8	11	9	5.6	T.	....
Brownsville	57	3	40	......	......	......	62.8	......	91	6	72	30	25	53	36	....	....	....	2.28	......	9	......	n.	36	......	22	....	....	....	....	....	....
Corpus Christi	20	69	77	30.10	30.12	+.07	56.9	- 0.8	81	6	64	29	25	49	36	53	50	84	0.44	- 1.6	8	8,113	n.	48	n.	6	3	11	14	7.0	0.5	....
Dallas	512	109	117	29.60	30.17	......	43.0	......	72	16	54	10	7	32	40	....	....	....	2.08	......	7	7,054	nw.	42	w.	6	8	9	11	6.1	T.	....
Fort Worth	670	106	114	29.41	30.14	+.07	44.3	- 3.8	77	22	55	12	7	34	45	39	32	66	1.17	- 0.1	7	7,663	s.	42	nw.	23	7	9	12	5.9	....	....
Galveston	54	106	114	30.10	30.16	+.09	52.8	- 2.8	73	6	59	27	24	47	37	49	46	80	3.31	+ 0.2	8	9,086	n.	40	nw.	6	4	12	12	6.3	0.5	....
Houston	138	111	121	29.99	30.15	......	52.9	- 1.1	78	4	62	24	7	44	43	....	....	....	3.32	......	7	6,525	se.	32	s.	22	9	10	9	6.0	T.	....
Palestine	510	64	72	29.60	30.15	+.07	47.3	- 3.6	75	3	57	17	7	38	45	42	39	78	2.92	- 0.5	9	5,271	n.	29	s.	22	9	6	13	6.2	T.	....
San Antonio	701	80	91	29.39	30.13	+.08	53.2	- 1.2	78	5	64	23	7	43	46	47	40	67	1.38	- 0.4	7	4,705	ne.	31	n.	6	10	8	10	5.5	....	....
Taylor	582	55	63	29.54	30.17	+.11	48.4	- 2.9	73	3	60	16	7	37	42	....	....	....	1.48	- 1.1	7	6,707	n.	32	s.	22	8	11	9	5.8	T.	....

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1914*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches. Station reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Ohio Valley and Tennessee.							**30.3**	**− 5.4**										**76**	**3.65**	**+ 0.1**										**5.8**		
Chattanooga	762	189	213	29.34	30.17	+ .04	41.7	− 2.0	68	23	51	19	8	33	38	36	31	71	3.97	− 1.0	10	5,810	nw.	45	sw.	23	7	11	10	5.7	2.2	....
Knoxville	996	93	100	29.06	30.15	+ .03	39.2	− 1.6	65	19	48	18	24	30	36	35	30	76	3.47	− 1.4	10	3,782	ne.	28	w.	23	7	6	15	6.2	2.0	....
Memphis	399	76	97	29.75	30.19	+ .08	40.2	− 3.1	66	17	49	12	7	31	40	36	31	74	3.15	− 1.2	12	6,885	n.	39	nw.	6	14	2	12	5.1	T.	....
Nashville	546	168	191	29.58	30.18	+ .06	38.0	− 3.1	68	6	48	14	24	28	41	34	29	74	2.03	− 2.3	11	7,355	nw.	46	se.	6	7	8	13	6.2	1.5	....
Lexington	989	75	102	29.07	30.19	+ .08	29.3	− 6.3	62	6	38	2	24	21	38	....	....	....	3.87	+ 0.6	14	8,073	s.	38	s.	7	11	5	12	5.6	5.3	T.
Louisville	525	219	255	29.59	30.20	+ .09	30.0	− 6.6	59	6	38	3	24	21	37	26	22	76	5.77	+ 2.0	11	9,365	n.	40	w.	7	7	6	15	6.3	7.1	T.
Evansville	431	72	82	29.69	30.18	+ .07	29.9	− 5.9	58	22	38	6	24	22	34	27	24	79	4.56	+ 1.5	12	5,706	ne.	26	s.	2	7	9	12	6.0	12.5	....
Indianapolis	822	154	164	29.26	30.19	.09	21.8	− 8.9	51	2	30	− 1	24	13	34	20	15	75	2.92	− 0.2	11	7,854	ne.	39	sw.	8	6	10	12	6.1	20.1	1.0
Terre Haute	575	96	129	29.54	30.18	+	22.7	......	49	17	31	1	24	14	34	21	18	80	3.05	......	10	8.069	ne.	40	nw.	28	4	12	12	6.4	17.5	T.
Cincinnati	628	152	160	29.48	30.20	+ .10	27.4	− 7.0	56	2	36	1	24	18	34	25	23	85	4.80	+ 1.6	12	5,492	se.	30	w.	7	9	9	10	5.7	21.4	1.0
Columbus	824	173	222	29.26	30.18	.09	23.6	− 7.4	51	6	33	− 1	24	14	34	21	17	78	3.70	+ 0.6	10	9,138	ne.	52	nw.	8	15	5	8	4.5	19.6	0.4
Dayton	899	181	216	29.17	30.17	+	23.1	− 6.9	51	2	32	− 3	25	14	35	21	17	81	3.33	+ 0.2	12	9,161	n.	48	sw.	8	11	6	11	5.4	15.2	0.8
Pittsburgh	842	353	410	29.23	30.18	+ .09	24.3	− 7.5	52	3	33	− 2	24	16	34	21	15	71	3.13	+ 0.5	15	8,995	w.	50	w.	7	9	6	13	6.0	23.4	4.8
Elkins	1,940	41	50	28.02	30.18	+ .08	28.0	− 3.5	58	3	38	−10	25	18	51	24	19	74	2.72	− 0.4	14	3,493	w.	24	w.	7	5	8	15	6.9	13.4	T.
Parkersburg	638	77	84	29.51	30.19	.09	27.6	− 6.3	55	2	37	− 7	25	18	38	23	18	73	3.74	+ 0.5	13	4,880	n.	35	nw.	16	11	9	8	5.4	23.4	3.0
Lower Lake Region.							**17.1**	**− 7.6**										**76**	**1.68**	**− 0.8**										**5.8**		
Buffalo	767	247	280	29.29	30.16	+ .10	16.9	− 7.1	46	28	24	− 9	12	10	26	15	11	80	1.95	− 0.9	13	12,192	sw.	88	sw.	7	5	13	10	5.8	21.4	6.0
Canton	448	10	61	29.66	30.17	+	8.3	− 9.7	48	28	18	−27	24	−1	41	....	....	....	1.16	− 1.4	7	7,959	w.	64	w.	1	18	6	4	2.6	14.1	0.5
Oswego	335	76	91	29.77	30.16	+ .10	16.2	− 7.7	48	28	24	−14	13	9	31	14	11	82	2.20	− 0.4	14	8,639	s.	45	w.	1	3	6	19	7.4	21.6	7.0
Rochester	523	86	102	29.57	30.17	+ .11	17.4	− 6.5	49	28	24	− 8	12	10	24	15	9	72	1.66	− 1.2	14	5,917	w.	44	w.	7	5	8	15	6.6	21.6	5.5
Syracuse	597	97	113	29.50	30.18	+ .11	15.6	− 8.2	49	3	24	−20	12	8	27	13	8	75	2.42	+ 0.6	15	8,420	nw.	49	sw.	7	10	7	11	5.2	22.0	5.0
Erie	714	92	102	29.36	30.17	+ .10	19.0	− 7.1	48	3	26	−10	13	12	32	17	12	75	1.49	− 1.4	16	8,286	w.	48	se.	6	3	10	15	6.8	15.3	1.0
Cleveland	762	190	201	29.32	30.19	+ .12	19.8	− 7.0	50	3	28	− 6	13	12	32	17	12	74	1.84	− 0.8	13	8,143	sw.	42	sw.	8	5	12	11	6.3	16.1	2.3
Sandusky	629	62	70	29.48	30.19	+ .12	19.8	− 7.3	49	3	28	− 6	24	12	30	17	13	79	1.86	− 0.5	11	10,147	sw.	48	sw.	7	4	12	12	6.3	10.4	1.0
Toledo	628	208	246	29.48	30.20	.13	19.1	− 7.7	45	3	27	− 4	24	11	30	16	12	74	1.24	− 0.7	7	11,457	sw.	56	sw.	7	7	14	7	5.4	8.1	T.
Fort Wayne	856	113	124	29.22	30.19	+	18.0	− 7.8	47	3	27	− 4	9	10	34	16	11	73	1.66	......	11	8,122	sw.	38	sw.	7	8	10	10	5.8	11.4	5.0
Detroit	730	218	258	29.35	30.18	.12	17.6	− 7.4	44	28	25	− 7	12	10	24	15	12	81	1.03	− 1.2	10	9,591	w.	46	w.	7	5	13	10	6.0	9.0	0.3
Upper Lake Region.							**11.8**	**− 7.4**										**79**	**1.04**	**− 0.7**										**5.9**		
Alpena	609	13	92	29.45	30.16	+ .13	11.2	− 6.6	46	27	20	−18	12	2	33	10	7	85	0.67	− 1.1	15	8,155	nw.	48	se.	28	4	17	7	5.6	10.0	4.5
Escanaba	612	54	60	29.47	30.18	+ .12	9.6	− 5.7	44	28	19	−15	12	1	40	8	4	79	1.11	− 0.2	8	6,613	nw.	36	n.	28	12	6	10	5.0	7.3	0.5
Grand Haven	632	54	92	29.46	30.19	+ .14	15.6	− 8.6	40	27	24	−10	12	8	29	15	11	80	1.49	− 0.4	15	8,917	e.	42	w.	1	5	10	13	6.5	21.8	6.5
Grand Rapids	707	70	87	29.38	30.19	+ .14	15.8	− 9.7	45	27	24	−10	12	8	28	14	10	79	0.75	− 1.2	11	3,880	e.	23	w.	1	5	10	13	6.2	14.6	6.5
Houghton	684	62	72	29.38	30.15	.10	7.3	− 8.7	47	27	16	−27	12	−2	40	....	....	....	1.93	+ 0.2	16	6,047	nw.	42	nw.	21	5	10	13	6.2	19.6	10.0
Lansing	878	11	62	29.18	30.18	....	12.7	− 8.9	44	27	24	−16	12	6	34	10	8	84	0.79	− 1.2	10	4,726	sw.	23	se.	2	6	13	9	5.7	9.2	3.0
Ludington	637	60	66	29.44	30.17	....	15.2	......	38	27	23	−12	13	7	27	15	10	78	1.59	......	14	8,818	e.	46	sw.	21	5	3	20	7.8	19.9	2.6
Marquette	734	77	111	29.34	30.19	+ .14	11.6	− 4.3	50	27	20	−11	10	3	40	9	4	76	1.55	− 0.2	14	8,869	w.	48	sw.	8	8	8	12	5.6	15.7	16.2
Port Huron	638	70	120	29.44	30.17	.12	15.2	− 6.8	41	27	24	− 7	13	7	29	13	10	81	0.69	− 1.5	8	7,990	sw.	35	w.	8	7	17	4	4.8	6.9	1.0
Saginaw	641	48	82	29.45	30.18	+	13.0	......	44	27	23	−14	13	3	34	11	9	86	0.78	− 1.3	6	6,904	sw.	36	nw.	7	4	14	10	6.2	9.4	4.2
Sault Sainte Marie	614	11	61	29.43	30.18	+ .15	6.2	− 7.2	43	27	16	−28	12	−3	38	5	2	86	1.08	− 0.3	13	6,342	nw.	42	nw.	21	7	7	14	6.4	12.4	14.5
Chicago	823	140	310	29.27	30.20	+ .12	20.2	− 5.2	48	28	27	− 6	8	13	30	18	12	68	0.93	− 1.2	12	8,702	sw.	38	ne.	23	7	8	13	6.0	7.2	0.5
Green Bay	617	109	144	29.48	30.18	+ .12	9.8	− 7.4	42	28	19	−13	12	0	33	8	4	75	0.83	− 0.8	6	8,351	sw.	46	n.	28	10	10	8	6.1	9.5	....
Milwaukee	681	119	133	29.41	30.18	+ .12	15.6	− 6.3	46	28	24	−10	8	8	31	14	8	70	1.34	− 0.6	12	8,604	nw.	34	e.	13	9	7	12	5.6	11.8	0.5
Duluth	1,133	11	47	28.92	30.22	.14	2.7	−10.9	45	26	13	−28	11	−8	43	0	− 3	82	0.64	− 0.4	7	9,966	nw.	49	w.	28	13	10	5	4.2	9.1	1.5
North Dakota.							**1.4**	**− 5.5**										**83**	**0.30**	**− 0.2**										**5.2**		
Moorhead	940	8	57	29.22	30.32	+ .21	−0.4	− 7.4	48	27	11	−30	7	−12	47	− 2	− 5	81	0.42	− 0.3	8	6,284	n.	36	nw.	28	16	8	4	3.5	4.2	1.3
Bismarck	1,674	8	57	28.39	30.31	+ .19	5.3	− 3.0	52	27	16	−32	7	−6	42	3	− 1	80	0.36	− 0.1	7	6,705	nw.	54	nw.	28	11	6	11	5.2	3.9	T.
Devils Lake	1,482	11	44	28.56	30.26	+ .15	−3.6	− 8.1	47	27	8	−33	6	−15	40	− 5	− 7	87	0.16	− 0.4	8	7,612	nw.	48	nw.	28	12	8	8	4.8	2.2	T.
Williston	1,872	40	47	28.13	30.25	+ .14	4.4	− 3.5	51	27	15	−34	6	−6	35	2	0	84	0.28	− 0.2	6	5,485	n.	48	nw.	28	6	3	19	7.2	2.5	T.
Upper Miss. Valley.							**18.9**	**− 5.7**										**80**	**1.60**	**− 0.1**										**5.5**		
Minneapolis	918	102	208	......	......	......	7.6	......	42	27	17	−19	11	−2	42	....	....	....	0.45	− 0.3	9	8,100	nw.	49	nw.	28	11	9	8	4.8	6.8	T.
St. Paul	837	201	236	29.29	30.25	+ .16	8.0	− 7.0	42	27	17	−19	11	−1	39	6	2	76	0.49	− 0.4	10	8,436	n.	52	nw.	28	11	9	8	4.9	5.3	0.2
La Crosse	714	11	48	29.42	30.24	+ .16	12.6	− 5.8	45	2	22	−14	8	3	34	....	....	....	0.49	− 0.6	7	3,997	n.	29	nw.	28	9	8	11	5.8	7.9	0.3
Madison	974	70	78	29.10	30.22	+ .15	12.1	− 7.5	43	28	21	−13	8	4	36	10	7	81	0.92	− 0.6	6	7,572	ne.	42	nw.	28	8	8	12	6.0	9.6	0.1
Charles City	1,015	10	49	29.09	30.23	+ .13	12.9	− 2.2	47	2	23	−16	8	3	38	11	8	84	0.47	− 0.5	8	5,455	nw.	36	nw.	28	7	14	7	5.3	8.5	T.
Davenport	606	71	79	29.52	30.23	+ .13	18.6	− 5.2	49	28	27	− 8	8	10	41	16	13	82	0.76	− 0.8	8	6,230	ne.	40	w.	28	5	11	12	6.6	7.9	T.
Des Moines	861	84	97	29.25	30.21	+ .10	19.7	− 4.4	51	2	29	− 9	8	10	35	17	13	77	1.24	+ 0.2	8	6,382	e.	39	nw.	28	7	5	16	6.4	14.8	....
Dubuque	698	81	96	29.44	30.24	+ .15	15.8	− 5.8	47	27	25	−12	8	7	37	14	11	83	1.16	− 0.2	9	4,938	nw.	36	nw.	28	7	9	12	6.4	11.5	0.3
Keokuk	614	64	78	29.51	30.21	+ .10	21.4	− 5.2	51	2	31	− 4	7	12	31	19	14	76	1.12	− 0.5	9	6,338	ne.	40	w.	28	11	11	6	4.8	12.3	T.
Cairo	356	87	93	29.77	30.16	+ .04	33.4	− 4.2	64	17	42	9	7	25	39	30	26	75	3.85	+ 0.5	10	7,023	n.	41	nw.	28	9	5	14	5.9	3.9	....
Peoria	609	11	45	29.52	30.22	+ .12	19.3	− 6.6	47	28	28	− 3	8	11	35	17	15	87	1.36	− 1.3	9	6,262	ne.	33	nw.	28	14	7	7	4.6	12.2	T.
Springfield, Ill	644	10	91	29.48	30.19	+ .09	21.3	− 7.8	47	17	30	1	25	13	32	20	17	83	2.53	− 0.2	9	7,158	ne.	36	nw.	15	10	9	9	5.5	18.4	1.5
Hannibal	534	74	109	29.59	30.19	+ .08	23.0	− 6.1	53	2	32	− 4	25	14	34	....	....	....	2.94	+ 1.3	8	7,304	ne.	47	ne.	22	13	6	9	5.2	20.7	1.0
St. Louis	567	265	303	29.54	30.18	+ .07	27.4	− 6.1	62	17	36	1	7	18	40	24	19	75	4.63	+ 1.9	10	9,293	ne.	60	nw.	28	13	6	9	5.2	23.5	T.
Missouri Valley.							**20.9**	**− 3.6**										**77**	**1.69**	**+ 0.4**										**5.5**		
Columbia, Mo	784	11	84	29.31	30.18	+ .07	25.6	− 4.5	55	2	35	− 3	7	16	31	....	....	....	2.51	+ 0.4	9	6,762	ne.	42	nw.	28	8	8	12	6.0	15.1	T.
Kansas City	963	161	181	29.10	30.18	+ .07	26.8	− 3.1	56	17	36	− 4	7	18	34	23	19	76	2.40	+ 0.8	9	9,059	n.	53	nw.	28	7	11	10	5.6	14.3	T.
St. Joseph	967	11	49	29.10	30.19	......	24.6	......	54	17	34	− 7	7	15	34	21	17	77	1.82	......	8	6,657	ne.	40	nw.	28	10	8	10	5.9	15.6	T.
Springfield, Mo	1,324	98	104	28.70	30.15	+ .04	31.2	− 2.4	62	17	41	− 2	7	22	35	28	24	77	2.26	0.0	9	7,505	se.	39	nw.	28	12	4	12	5.1	7.5	....
Iola	984	11	50	29.07	30.17	+ .07	30.0	− 2.0	60	17	40	− 2	7	20	36	....	....	....	3.60	+ 2.5	7	5,877	s.	34	ne.	22	11	11	6	4.6	13.5	....
Topeka	983	85	101	......	......	......	27.2	− 2.8	62	17	36	− 4	7	18	36	....	....	....	1.40	0.0	7	7,189	n.	35	n.	28	7	10	11	5.7	8.4	....
Lincoln	1,189	11	84	28.88	30.21	+ .11	22.4	− 2.4	52	17	32	−10	7	13	31	20	15	76	0.71	0.0	9	8,712	ne.	56	nw.	28	12	3	13	5.5	11.2	T.
Omaha	1,105	115	121	28.48	30.22	+ .11	21.4	− 2.3	50	28	31	−11	7	12	33	18	12	69	0.87	+ 0.1	8	7,378	s.	46	nw.	28	11	7	10	5.4	12.3	....
Valentine	2,598	47	54	27.37	30.24	+ .15	16.4	− 4.8	60	16	29	−28	7	4	54	13	10	82	0.56	0.0	7	6,229	nw.	36	nw.	28	12	4	12	5.2	5.8	T.
Sioux City	1,135	94	164	28.95	30.24	+ .12	16.0	− 3.8	50	16	26	−18	7	6	47	14	10	79	0.52	0.0	9	9,453	nw.	68	nw.	28	11	8	9	5.5	6.4	....
Huron	1,306	56	67	28.80	30.30	+ .18	7.2	− 5.7	44	1	18	−33	7	−4	42	6	3	87	0.79	+ 0.4	9	7,428	nw.	54	nw.	28	12	8	8	4.8	11.4	0.6
Pierre	1,572	70	75	28.54	30.31	+ .20	10.4	− 6.5	50	16	20	−23	7	1	37	8	3	72	1.35	+ 0.9	9	6,467	e.	43	nw.	28	12	9	7	5.3	17.1	1.5
Yankton	1,233	49	57	28.83	30.23	+ .11	15.7	− 2.5	57	16	26	−19	7	5	51	....	....	....	0.86	+ 0.3	12	5,473	nw.	30	nw.	28	7	10	11	6.3	10.2	T.

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1914*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches: Station reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches: Total.	Departure from normal.	Days with 0.01 or more.	Wind: Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Northern Slope.							**19.9**	**− 1.6**										**75**	**0.95**	**+ 0.2**										**6.0**		
Havre	2,505	11	44	27.42	30.22	+ .15	7.6	− 7.4	45	27	19	−43	6	−4	40	7	4	87	1.04	+ 0.6	8	5,192	e.	38	sw.	27	4	11	13	6.8	10.4	1.0
Helena	4,110	87	114	25.80	30.14	+ .03	23.9	+ 1.7	52	27	32	−26	6	16	35	20	15	69	1.05	+ 0.3	8	4,501	sw.	33	sw.	1	3	8	17	7.1	15.1	0.2
Kalispell	2,962	11	34	26.98	30.16	+ .08	22.3	− 1.5	47	27	31	−18	5	14	26	21	18	83	1.68	+ 0.2	14	2,246	w.	22	sw.	27	3	7	18	7.3	16.2	0.8
Miles City	2,371	26	48	27.56	30.24	+ .15	15.9	− 0.9	51	27	27	−32	6	5	36	13	9	78	0.95	+ 0.4	7	3,838	ne.	26	w.	27	11	11	6	4.8	10.6	T.
Rapid City	3,234	46	50	26.64	30.25	+ .17	17.6	− 5.9	60	16	29	−23	6	6	43	15	10	75	0.95	+ 0.5	9	4,216	w.	34	n.	2	9	6	13	6.0	9.8	1.0
Cheyenne	6,088	58	64	23.93	30.11	+ .08	25.6	− 0.7	56	16	36	−22	6	15	44	21	15	67	0.23	− 0.3	4	10,268	w.	44	w.	3	7	11	10	5.6	2.4	T.
Lander	5,372	60	68	24.60	30.14	+ .06	22.7	+ 0.9	54	21	38	−27	6	8	49	18	11	63	0.76	+ 0.1	5	2,730	sw.	32	sw.	21	14	10	4	4.4	8.2	T.
Sheridan	3,790	10	47	26.11	30.18	...	20.6	...	55	16	34	−27	6	7	40	17	14	78	1.25	...	10	3,416	nw.	30	nw.	4	4	11	13	6.2	14.7	...
Yellowstone Park	6,200	11	48	23.82	30.16	+ .06	20.1	+ 0.5	44	16	29	−29	6	11	32	18	13	72	0.91	− 0.9	9	5,817	s.	34	sw.	27	5	4	19	7.5	6.0	2.3
North Platte	2,821	11	51	27.16	30.22	+ .15	23.3	− 1.3	64	16	36	−15	6	10	46	19	14	74	0.96	+ 0.6	9	4,934	n.	30	nw.	15	14	7	7	4.6	9.7	0.8
Middle Slope.							**31.4**	**− 1.0**										**69**	**0.75**	**0.0**										**4.1**		
Denver	5,291	129	172	24.68	30.09	+ .08	31.3	+ 0.2	70	21	44	−15	6	19	47	24	16	60	0.39	− 0.1	3	5,077	sw.	35	nw.	7	18	7	3	3.3	5.6	...
Pueblo	4,685	80	86	25.26	30.07	+ .07	32.0	+ 0.2	72	21	46	−11	7	18	50	25	16	58	0.36	− 0.1	3	4,019	nw.	34	w.	21	21	3	4	2.9	5.7	...
Concordia	1,398	42	50	28.66	30.20	+ .11	26.6	− 2.2	58	17	37	− 7	7	16	36	23	20	80	0.82	+ 0.1	7	5,331	n.	28	nw.	28	10	8	10	5.8	7.5	T.
Dodge City	2,509	11	51	27.46	30.16	+ .10	30.0	− 1.1	72	21	44	− 7	7	16	51	24	18	68	0.47	− 0.2	5	7,426	nw.	44	nw.	22	17	3	8	4.1	4.1	...
Wichita	1,358	139	158	28.64	30.13	+ .05	32.0	− 1.0	65	22	43	− 2	7	21	55	27	22	74	1.58	+ 0.5	7	9,233	s.	45	n.	6	16	5	7	4.0	6.4	...
Oklahoma	1,214	10	47	28.83	30.15	+ .08	36.7	− 1.8	72	22	49	3	7	24	58	31	26	74	0.86	− 0.1	4	11,109	s.	56	nw.	22	14	8	6	4.5	0.3	...
Southern Slope.							**44.6**	**+ 0.1**										**57**	**0.31**	**− 0.8**										**4.6**		
Abilene	1,738	10	52	28.29	30.14	+ .09	44.0	− 0.8	74	22	58	10	7	30	44	37	28	60	0.14	− 0.9	1	7,551	s.	50	w.	22	5	8	15	6.5	T.	...
Amarillo	3,676	10	49	26.28	30.09	+ .07	38.2	+ 1.0	77	17	54	− 1	6	22	57	30	22	64	0.10	− 0.8	3	7,225	sw.	36	sw.	1	21	5	2	3.3	0.8	...
Del Rio	944	8	57	29.12	30.12	+ .12	53.4	− 0.2	81	20	65	24	25	42	42	...	...	...	0.90	− 0.9	6	4,911	se.	31	n.	6	9	12	7	5.1	...	...
Roswell	3,566	75	85	26.39	30.05	+ .07	42.8	+ 0.3	76	21	60	8	7	26	48	34	21	47	0.11	− 0.5	2	5,676	s.	48	nw.	22	16	11	1	3.5	0.4	...
Southern Plateau.							**44.6**	**− 0.2**										**51**	**0.50**	**− 0.2**										**3.2**		
El Paso	3,762	110	133	26.21	30.02	+ .07	49.0	+ 0.1	72	21	62	26	25	36	37	38	20	37	0.53	+ 0.1	2	7,374	w.	44	w.	5	13	13	2	3.6	2.5	...
Santa Fe	7,013	57	62	23.21	30.07	+ .09	32.6	+ 0.6	55	21	43	11	7	22	32	25	15	50	0.63	− 0.2	7	4,541	n.	27	n.	8	14	12	2	3.5	5.9	T.
Flagstaff	6,908	8	57	...	...	...	29.8	− 1.0	53	28	42	2	2	18	42	26	...	...	1.43	...	5	...	w.	31	sw.	21	13	9	6	...	2.0	T.
Phoenix	1,108	76	81	28.87	30.04	+ .05	55.1	+ 0.7	77	10	68	32	7	42	39	46	35	53	0.71	0.0	6	3,217	e.	29	sw.	21	15	5	8	4.2	...	...
Yuma	141	9	58	29.90	30.05	+ .05	60.0	+ 0.8	83	11	73	34	5	47	38	47	32	41	0.32	− 0.3	3	4,907	n.	34	nw.	21	24	2	2	1.6	...	...
Independence	3,910	11	42	26.08	30.14	+ .08	41.0	− 2.7	64	28	54	20	2	28	36	35	29	70	0.30	− 0.5	2	3,109	n.	44	s.	20	15	10	3	2.9	...	...
Middle Plateau.							**33.6**	**+ 1.1**										**66**	**0.84**	**− 0.3**										**4.4**		
Reno	4,532	74	81	25.52	30.14	+ .06	37.8	+ 2.2	63	28	49	16	2	26	31	32	24	62	0.86	− 0.9	5	3,563	w.	36	sw.	19	13	7	8	4.6	0.7	...
Tonopah	6,090	12	20	24.08	30.10	...	36.0	...	57	28	43	18	6	29	23	30	21	56	0.59	− 0.2	3	6,109	se.	42	nw.	5	16	5	7	3.8	T.	...
Winnemucca	4,344	18	56	25.68	30.15	+ .06	36.4	+ 3.1	62	28	48	15	6	25	32	31	25	67	0.51	− 0.4	8	4,537	sw.	38	sw.	20	12	5	11	4.7	0.3	...
Modena	5,479	10	43	24.65	30.11	+ .07	32.6	+ 1.0	58	28	43	7	7	22	33	28	21	66	0.98	− 0.2	5	5,504	w.	38	sw.	19	15	4	9	4.4	1.0	...
Salt Lake City	4,360	147	189	25.70	30.16	+ .08	34.5	+ 1.6	60	28	42	11	6	28	23	30	26	71	0.98	− 0.4	8	3,702	se.	32	nw.	5	7	14	7	5.2	3.8	...
Durango	6,546	18	56	23.63	30.12	+ .12	27.4	− 2.5	50	28	41	0	7	14	37	22	16	68	1.46	+ 0.1	5	3,486	nw.	25	ne.	22	17	7	4	3.1	7.3	...
Grand Junction	4,602	43	51	25.44	30.10	+ .06	32.9	+ 1.4	57	21	42	11	2	24	26	28	22	69	0.49	− 0.1	6	3,911	se.	32	se.	21	10	9	9	4.9	2.9	...
Northern Plateau.							**32.7**	**+ 0.6**										**75**	**1.22**	**− 0.2**										**7.8**		
Baker	3,471	48	53	26.53	30.22	+ .10	27.4	− 0.5	46	22	36	− 6	6	19	29	26	22	77	0.94	− 0.4	11	4,122	se.	23	se.	21	5	9	14	6.5	8.2	...
Boise	2,739	78	86	27.29	30.22	+ .10	36.0	+ 2.2	58	28	43	7	6	29	21	32	26	67	0.98	− 0.4	12	3,281	nw.	28	e.	20	2	5	21	8.3	2.8	...
Lewiston	757	40	48	29.32	30.16	+ .05	37.2	+ 1.0	59	27	44	5	6	30	21	...	...	...	0.76	− 0.6	14	2,886	e.	27	s.	27	3	8	17	7.7	1.8	...
Pocatello	4,477	46	54	25.53	30.19	+ .09	28.1	0.0	50	20	37	− 9	6	19	36	26	22	77	1.32	+ 0.5	10	6,077	se.	36	sw.	1	3	7	18	7.1	9.6	...
Spokane	1,929	101	110	28.05	30.16	+ .07	31.4	+ 1.3	50	27	37	− 1	5	26	24	30	26	77	1.72	− 0.2	10	3,708	ne.	27	sw.	27	3	0	25	8.6	4.1	...
Walla Walla	1,000	107	115	29.08	30.18	+ .07	36.3	− 0.1	60	26	42	10	5	31	24	33	30	78	1.59	0.0	11	3,045	s.	23	w.	1	2	4	22	8.6	3.4	...
North Pacific Coast Region.							**42.9**	**+ 2.3**										**84**	**3.43**	**− 2.1**										**7.5**		
North Head	211	11	56	29.86	30.10	+ .04	44.9	+ 2.8	59	15	48	31	5	41	15	44	42	88	5.27	− 0.5	20	11,102	e.	65	se.	23	3	7	18	7.8	...	...
Port Crescent	259	8	53	29.79	30.07	+ .04	39.4	+ 2.2	51	19	45	26	5	34	20	...	...	...	2.39	− 2.3	14	3,859	se.	22	sw.	3	0	10	18	7.9	T.	...
Seattle	125	215	250	29.98	30.11	+ .05	42.3	+ 2.8	61	20	48	26	5	37	17	41	39	86	1.93	− 1.9	14	4,959	se.	37	sw.	28	3	9	16	7.6	0.4	...
Tacoma	213	113	120	29.87	30.11	+ .05	42.0	+ 1.6	57	20	48	26	3	36	20	40	38	85	2.71	− 2.4	16	3,474	sw.	25	sw.	4	0	7	21	8.1	T.	...
Tatoosh Island	86	7	57	29.94	30.04	+ .04	43.5	+ 2.5	52	20	46	31	5	40	12	42	40	87	5.31	− 3.4	18	13,148	e.	62	s.	28	5	10	13	7.0	T.	...
Portland, Oreg.	153	68	106	29.96	30.12	+ .04	43.4	+ 2.1	57	26	48	28	6	39	19	40	37	79	4.19	− 1.5	17	4,336	se.	28	s.	21	4	5	19	7.5	T.	...
Roseburg	510	9	57	29.57	30.13	+ .03	44.5	+ 1.9	66	26	52	27	7	37	30	42	38	80	2.21	− 2.4	17	1,693	s.	20	sw.	28	0	17	11	6.8	...	...
Middle Pacific Coast Region.							**50.5**	**+ 1.5**										**75**	**4.22**	**− 0.1**										**4.8**		
Eureka	62	73	89	30.06	30.13	+ .02	47.9	+ 1.1	65	15	54	33	6	41	23	46	44	85	4.20	− 2.8	16	4,111	se.	43	w.	20	8	7	13	6.3	...	...
Mt. Tamalpais	2,375	11	18	27.61	30.11	+ .01	46.7	+ 1.1	63	28	51	35	5	42	17	42	37	72	3.79	− 1.9	9	11,322	nw.	64	nw.	5	13	7	8	4.7	...	...
Point Reyes Light	490	7	18	29.54	30.06	...	52.1	+ 2.9	68	14	56	44	5	48	19	...	...	...	2.15	...	9	12,203	nw.	80	s.	20	10	9	9	5.5	...	...
Red Bluff	332	50	56	29.75	30.11	.00	50.6	+ 1.3	70	14	60	32	4	42	29	44	37	66	5.40	+ 1.8	6	3,870	n.	26	nw.	1	11	8	9	4.9	...	...
Sacramento	69	106	117	30.04	30.12	+ .03	51.1	+ 0.9	65	28	58	35	6	44	22	48	44	77	2.96	− 0.2	6	4,812	se.	42	se.	20	17	3	8	4.0	...	...
San Francisco	155	200	204	29.94	30.11	+ .01	54.0	+ 2.7	67	28	60	43	4	48	19	49	45	77	5.04	+ 1.3	8	3,686	s.	35	s.	20	16	5	7	3.9	...	...
San Jose	141	12	110	29.96	30.10	...	51.4	+ 0.8	72	28	62	31	2	41	35	...	...	...	3.94	+ 1.4	8	3,644	se.	35	se.	20	16	4	8	4.2	...	...
South Pacific Coast Region.							**56.1**	**+ 3.5**										**71**	**3.39**	**+ 0.9**										**4.6**		
Fresno	327	89	98	29.77	30.13	+ .05	52.2	+ 3.0	72	28	62	35	7	43	28	48	45	77	1.31	0.0	6	3,374	nw.	36	s.	20	8	11	9	5.7	...	...
Los Angeles	338	159	191	29.70	30.07	+ .01	59.4	+ 5.3	79	14	68	41	3	50	26	51	44	64	7.04	+ 4.1	4	4,234	ne.	36	se.	20	14	5	9	4.5	...	...
San Diego	87	62	70	29.97	30.06	.00	57.4	+ 2.8	78	15	65	43	12	50	23	52	47	74	1.90	− 0.1	7	4,351	nw.	45	s.	20	13	6	9	4.4	...	...
San Luis Obispo	201	47	54	29.89	30.11	.00	55.5	+ 3.0	77	14	65	35	3	46	35	50	45	70	3.31	− 0.3	7	3,949	n.	33	s.	20	16	4	8	3.9	...	...
West Indies.																																
San Juan	82	8	54	29.95	30.04	− .01	74.6	...	85	15	80	64	27	69	19	...	...	...	3.02	+ 0.5	18	9,134	e.	48	nw.	22	8	16	4	4.7	...	...
Panama.																																
Ancon	92	6	69	29.76	29.85	...	81.8	...	94	7	92	65	25	72	26	73	71	80	0.02	− 0.7	2	7,364	nw.	25	nw.	15	16	10	2	4.0	...	...
Culebra	404	5	62	29.46	29.87	...	79.6	...	90	3	88	66	24	71	23	72	70	84	0.20	− 0.4	4	7,410	nw.	29	n.	17	7	20	1	4.4	...	...
Colon	10	5	71	29.88	29.89	...	80.9	...	86	7	85	73	24	77	12	75	73	80	1.32	− 0.2	13	10,504	n.	30	ne.	1	11	15	2	4.6	...	...

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during February, 1914, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	18			0.14														.07			
Albany, N. Y	13–14			1.59														(*)			
Alpena, Mich	6–7			0.34														(*)			
Amarillo, Tex	27			0.06														(*)			
Anniston, Ala																					
Asheville, N. C	6			0.46														.25			
Atlanta, Ga	6			2.05														.60			
Atlantic City, N. J	6			0.36														.12			
Augusta, Ga	6			1.07														.25			
Baker, Oreg	10			0.26														(*)			
Baltimore, Md	13–14			1.02														(*)			
Bentonville, Ark	3			0.55														.36			
Binghamton, N. Y	13–14			1.93														.14†			
Birmingham, Ala	6			0.75														.26			
Bismarck, N. Dak	5			0.12														(*)			
Block Island, R. I	6			0.71														.20			
Boise, Idaho	10			0.17														.06			
Boston, Mass	14			1.49														.31			
Buffalo, N. Y	22			0.46														(*)			
Burlington, Vt	14			0.36														(*)			
Cairo, Ill	18			1.84														.30			
Canton, N. Y	6–7			0.39														(*)			
Charles City, Iowa	6			0.16														(*)			
Charleston, S. C	20	3.00 a. m.	4.15 p. m.	2.24	3.57 a. m.	4.17 a. m.	.29	.20	.50	.56	.67										
Charlotte, N. C	6			0.83														.35			
Chattanooga, Tenn	6			1.48														.37			
Cheyenne, Wyo	22–23			0.11														(*)			
Chicago, Ill	6–7			0.36														(*)			
Cincinnati, Ohio	6			0.78														.33			
Cleveland, Ohio	22			0.62														(*)			
Columbia, Mo	18–19			0.98														(*)			
Clumbia, S. C	23			0.59														.25			
Columbus, Ohio	6			0.60														.28			
Concord, N. H	14			0.96														(*)			
Concordia, Kans	12			0.30														(*)			
Corpus Christi, Tex	11			0.27														.04			
Davenport, Iowa	6–7			0.39														(*)			
Dayton, Ohio	18–19			1.01														(*)			
Del Rio, Tex	11–12			0.52														.28			
Denver, Colo	22			0.29														(*)			
Des Moines, Iowa	12			0.38														(*)			
Detroit, Mich	6–7			0.51														(*)			
Devils Lake, N. Dak	1–2			0.04														(*)			
Dodge City, Kans	12			0.32														(*)			
Dubuque, Iowa	6			0.66														(*)			
Duluth, Minn	2			0.36														(*)			
Durango, Colo	19			0.55														(*)			
Eastport, Me	14			0.82														(*)			
Elkins, W. Va	18–19			0.91†														(*)			
El Paso, Tex	17			0.35														.26			
Erie, Pa	7–8			0.26														(*)			
Escanaba, Mich	2			0.72														(*)			
Eureka, Cal	24			0.44														.33			
Evansville, Ind	18			2.49														.30			
Flagstaff, Ariz	21			0.65														(*)			
Fort Smith, Ark	12			0.96														.27			
Fort Wayne, Ind	22–23			0.60														(*)			
Fort Worth, Tex	5			0.14														.13			
Fresno, Cal	20			0.72														.25			
Galveston, Tex	12	7.20 a. m.	6.20 p. m.	1.69	5.40 p. m.	5.56 p. m.	1.16	.14	.31	.47	.50										
Grand Haven, Mich	15–16			0.34														(*)			
Grand Junction, Colo	22			0.23														(*)			
Grand Rapids, Mich	6–7			0.17														(*)			
Green Bay, Wis	6			0.37														(*)			
Hannibal, Mo	22–23			1.02														(*)			
Harrisburg, Pa	13–14			1.80														(*)			
Hartford, Conn	13–14			1.30														(*)			
Hatteras, N. C	6			0.95														.77			
Havre, Mont	1–2			0.50														(*)			
Helena, Mont	21			0.49														(*)			
Houghton, Mich	8–9			0.53														(*)			
Houston, Tex	12			1.15														.47			
Huron, S. Dak	11–12			0.23														(*)			
Independence, Cal	20			0.29														.09			
Indianapolis, Ind	18–19			1.04														(*)			
Iola, Kans	12			1.66														.23			
Jacksonville, Fla	28			1.98														.40			
Kalispell, Mont	4			0.54														(*)			
Kansas City, Mo	18			0.87														(*)			
Keokuk, Iowa	22–23			0.31														(*)			
Key West, Fla	3			0.47														.16			
Knoxville, Tenn	6			1.27														.38			
La Crosse, Wis	6			0.33†														(*)			
Lander, Wyo	25–26			0.42														(*)			
Lansing, Mich	6–7			0.49														(*)			
Lewiston, Idaho	10			0.40														.14			
Lexington, Ky	19			0.77														(*)			
Lincoln, Nebr	22–23			0.27														(*)			
Little Rock, Ark	22			0.56														.30			
Los Angeles, Cal	18	11.30 a. m.	7.45 p. m.	3.10	12.27 p. m.	1.56 p. m.	.18	.06	.11	.21	.29	.32	.35	.41	.45	.55	.63	.86	1.73	1.90	
Louisville, Ky	18			1.84														.24			
Ludington, Mich	2–3			0.40														(*)			
Lynchburg, Va	6			0.62														.16			
Macon, Ga	6			1.15														.21			
Madison, Wis	6			0.67														(*)			

* Self-register not working. † Record partly estimated.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during February, 1914, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min	60 min.	80 min.	100 min.	120 min.
Marquette, Mich.	3-4			0.37														(*)			
Memphis, Tenn.	4			0.44														.34			
Meridian, Miss.	6	1.30 p.m.	4.50 p.m.	0.58	2.04 p.m.	2.20 p.m.	.04	.10	.22	.37	.45										
Miami, Fla.	20			0.23														.22			
Milwaukee, Wis.	6-7			0.68														(*)			
Minneapolis, Minn.	6			0.19														(*)			
Mobile, Ala.	6	D. N. a.m.	8.10 a.m.	2.05	6.08 a.m.	7.14 a.m.	.29	.13	.20	.24	.30	.36	.59	1.10	1.24	1.27	1.29	1.45	1.71		
	12-13	5.12 p.m.	6.10 a.m.	2.36	1.16 a.m.	2.17 a.m.	.54	.17	32	.46	.59	.69	.74	.81	.87	.97	1.16	1.39	1.49		
Modena, Utah	21			0.60														.10			
Montgomery, Ala.	5			0.70														.22			
Moorhead, Minn.	5			0.09														(*)			
Mount Tamalpais, Cal.	22			0.86														.26			
Mount Weather, Va.	13			0.60														(*)			
Nantucket, Mass.	7			0.70														.42			
Nashville, Tenn.	6			0.49														.28			
New Haven, Conn.	13-14			1.82														(*)			
New Orleans, La.	12-13	2.40 p.m.	6.05 a.m.	2.18	11.12 p.m.	11.27 p.m.	1.36	.09	.33	.46											
New York, N. Y.	14			1.59														.26			
Norfolk, Va.	13			1.09														.20			
Northfield, Vt.	14			1.33														(*)			
North Head, Wash.	24			0.29														.17			
North Platte, Nebr.	22-23			0.57														(*)			
Oklahoma, Okla.	18			0.67														.14			
Omaha, Nebr.	22-23			0.46														(*)			
Oswego, N. Y.	7-8			0.97														(*)			
Palestine, Tex.	5	3.50 p.m.	5.55 p.m.	0.82	5.22 p.m.	5.30 p.m.	.37	.31	.43												
Parkersburg, W. Va.	18-19			1.26														(*)			
Pensacola, Fla.	13			1.53														.46			
Peoria, Ill.	22-23			0.51														(*)			
Philadelphia, Pa.	13-14			1.37														(*)			
Phoenix, Ariz.	21			0.54														.18			
Pierre, S. Dak.	21-22			0.68														(*)			
Pittsburgh, Pa.	18-19			1.14														(*)			
Pocatello, Idaho	21			0.34														.19			
Point Reyes Light, Cal.	18			0.46														.19			
Port Huron, Mich.	6-7			0.28														(*)			
Portland, Me.	14			2.27														.37			
Portland, Oreg.	12			0.29														.22			
Providence, R. I.	13-14			1.16														(*)			
Pueblo, Colo.	22			0.26														(*)			
Raleigh, N. C.	20			1.39														.24			
Rapid City, S. Dak.	21-22			0.60														(*)			
Reading, Pa.	13-14			1.29														(*)			
Red Bluff, Cal.	20			2.71														.46			
Reno, Nev.	20			0.42														(*)			
Richmond, Va.	6			0.68														.16			
Rochester, N. Y.	13-14			0.54														(*)			
Roseburg, Oreg.	20			0.30														.12			
Roswell, N. Mex.	27			0.10														(*)			
Sacramento, Cal.	18			0.58														.17			
Saginaw, Mich.	6-7			0.38														(*)			
St. Joseph, Mo.	22-23			1.05														(*)			
St. Louis, Mo.	18-19			1.92														(*)			
St. Paul, Minn.	6			0.17														(*)			
Salt Lake City, Utah	21-22			0.37														(*)			
San Antonio, Tex.	12			0.65														.43			
San Diego, Cal.	21			0.65														.33			
Sand Key, Fla.	3			0.55														.20			
Sandusky, Ohio	6-7			0.97														(*)			
San Francisco, Cal.	17			0.47														.43			
San Jose, Cal.	18			0.73														.35			
San Luis Obispo, Cal.	20			1.71														.39			
Santa Fe, N. Mex.	26-27			0.38														(*)			
Sault Ste. Marie, Mich.	2-3			0.38														(*)			
Savannah, Ga.	20	1.05 a.m.	10.55 a.m.	2.15	1.45 a.m.	2.33 a.m.	.23	.11	.27	.36	.49	.51	.54	.60	.69	.79	.84				
Scranton, Pa.	13-14			3.58														(*)			
Seattle, Wash.	23			0.27														.08			
Sheridan, Wyo.	21-22			0.64														(*)			
Shreveport, La.	5	5.30 p.m.	7.25 p.m.	0.71	6.45 p.m.	7.11 p.m.	.06	.13	.39	.42	.46	.59	.64								
Sioux City, Iowa	5-6			0.25														(*)			
Spokane, Wash.	24			0.66														(*)			
Springfield, Ill.	18			0.85														(*)			
Springfield, Mo.	18-19			1.16														(*)			
Syracuse, N. Y.	13-14			1.58														(*)			
Tacoma, Wash.	28			0.51														.24			
Tampa, Fla.	10			1.04														.38			
Tatoosh Island, Wash.	26			1.03														.28			
Taylor, Tex.	27			0.99														.19			
Terre Haute, Ind.	18-19			1.24														(*)			
Thomasville, Ga.	6	9.20 a.m.	5.45 p.m.	2.13	Noon.	12.53 p.m.	.26	.06	.12	.19	.23	.28	.39	.53	.66	.73	.79	.86			
	6	6.36 p.m.	Midnight.	1.61	10.38 p.m.	11.38 p.m.	.16	.09	.13	.17	.30	.37	.39	.42	.65	.98	1.28	1.42			
Toledo, Ohio	6			0.46														(*)			
Tonopah, Nev.	20-21			0.51														(*)			
Topeka, Kans.	22-23			0.57														(*)			
Valentine, Nebr.	21-22			0.38														(*)			
Vicksburg, Miss.	5	D. N. a.m.	9.00 a.m.	2.33	3.11 a.m.	3.24 a.m.	.44	.34	.62	.75											
Walla Walla, Wash.	24-25			0.54														(*)			
Washington, D. C.	13-14			1.14														(*)			
Wichita, Kans.	12			0.98														(*)			
Williston, N. Dak.	2			0.11														(*)			
Wilmington, N. C.	20			1.92														.56			
Winnemucca, Nev.	20-21			0.32														.22			
Wytheville, Va.	12-13			1.00†														(*)			
Yankton, S. Dak.	22			0.32														(*)			
Yellowstone Park, Wyo.	21			0.42														(*)			

* Self-register not working.

† Record partly estimated.

TABLE III.—*Data furnished by the Canadian Meteorological Service, February, 1914.*

Districts and stations.	Pressure.			Temperature.						Precipitation.		
	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, Newfoundland	29.62	29.76	−.07	15.0	−7.0	22.3	7.7	46	− 5	2.58	−2.33	18.0
Sydney, Cape Breton Island	29.90	29.94	+.02	14.3	−5.0	24.1	4.5	48	−16	3.00	−1.09	23.0
Halifax, Nova Scotia	29.89	30.00	+.05	17.7	−4.7	28.3	7.2	47	−13	4.53	−0.63	21.0
Yarmouth, Nova Scotia	29.96	30.04	+.05	21.5	−4.3	29.5	13.5	47	− 6	3.92	−0.82	26.1
Charlottetown, Prince Edward Island	29.92	29.96	+.01	10.4	−7.2	20.7	0.0	42	−20	2.96	−0.10	23.6
Chatham, New Brunswick	29.98	30.01	+.05	4.0	−8.5	13.3	− 5.2	45	−28	2.34	−0.82	22.0
Father Point, Quebec	29.99	30.02	+.04	3.2	−8.3	12.5	− 6.2	44	−28	1.52	−0.69	15.2
Quebec, Quebec	29.73	30.07	+.08	3.4	−8.4	12.5	− 5.6	41	−31	2.49	−0.78	24.9
Montreal, Quebec	29.90	30.13	+.11	8.0	−6.5	16.3	− 0.4	41	−27	1.57	−1.50	14.9
Stonecliffe, Ontario	29.47	30.12	+.11	2.0	−7.9	16.6	−12.6	48	−42	2.48	+0.48	24.8
Ottawa, Ontario	29.88	30.23	+.21	6.2	−5.5	16.5	− 4.1	42	−28	1.13	−1.56	11.3
Kingston, Ontario	29.84	30.18	+.14	11.0	−6.8	20.7	1.4	40	−23	0.60	−1.94	5.3
Toronto, Ontario	29.74	30.14	+.10	15.5	−6.0	23.3	7.7	45	−18	1.87	−0.74	12.8
White River, Ont	28.72	30.14	+.12	− 9.7	−9.9	9.2	−28.6	40	−56	0.80	−0.72	8.0
Port Stanley, Ontario	29.51	30.18	+.12	15.4	−7.4	24.3	6.6	39	−11	2.22	−0.99	15.1
Southampton, Ontario	29.41	....	....	13.6	−6.3	22.0	5.2	41	21	2.65	−0.25	26.5
Parry Sound, Ontario	29.41	30.16	+.15	7.0	−7.3	19.0	− 5.0	42	−33	2.30	−0.62	23.0
Port Arthur, Ontario	29.43	30.20	+.15	0.9	−5.5	13.2	−11.4	46	−37	0.39	−0.51	3.9
Winnipeg, Manitoba	29.38	30.30	+.20	− 8.8	−7.2	1.3	−18.8	39	−40	0.83	−0.15	8.2
Minnedosa, Manitoba	28.30	30.27	+.18	− 8.0	−5.3	3.6	−19.6	39	−45	0.30	−0.31	3.0
Qu'Appelle, Saskatchewan	27.78	30.20	+.12	− 2.3	−1.7	9.4	−14.0	44	−41	0.32	−0.41	3.2
Medicine Hat, Alberta	27.74	30.14	+.09	9.6	−1.6	19.7	0.5	47	−39	0.80	+0.13	8.0
Swift Current, Saskatchewan	27.44	30.18	+.11	4.4	−3.6	14.5	− 5.8	46	−37	0.38	−0.36	3.8
Calgary, Alberta	26.40	30.10	+.11	16.5	+3.0	28.6	4.3	55	−29	1.15	+0.52	11.5
Banff, Alberta	25.32	30.12	+.14	17.8	−1.4	28.8	6.9	40	−42	0.25	−0.67	2.5
Edmonton, Alberta	27.75	30.18	+.16	7.9	−0.4	19.0	− 3.2	51	−36	1.07	+0.40	10.6
Prince Albert, Saskatchewan	28.54	30.22	+.13	− 5.2	−2.2	7.8	−18.2	47	−47	0.06	−0.63	0.6
Battleford, Saskatchewan	28.37	30.25	+.16	− 4.4	−4.5	5.0	−13.7	45	−46	0.40	+0.03	4.0
Kamloops, British Columbia	28.86	30.18	+.22	25.2	−3.1	30.7	19.7	52	−18	2.18	+1.39	21.3
Victoria, British Columbia	29.98	30.08	+.08	42.0	+2.5	46.1	37.9	53	26	1.56	−2.54	0.3
Barkerville, British Columbia	25.59	30.01	+.10	20.9	+2.0	28.4	13.3	38	−25	3.60	+0.54	36.0
Hamilton, Bermuda	29.98	30.15	+.04	61.0	−0.5	66.0	55.9	71	48	10.40	+5.96	0.0

Chart I. Hydrographs of Several Principal Rivers, February, 1914.

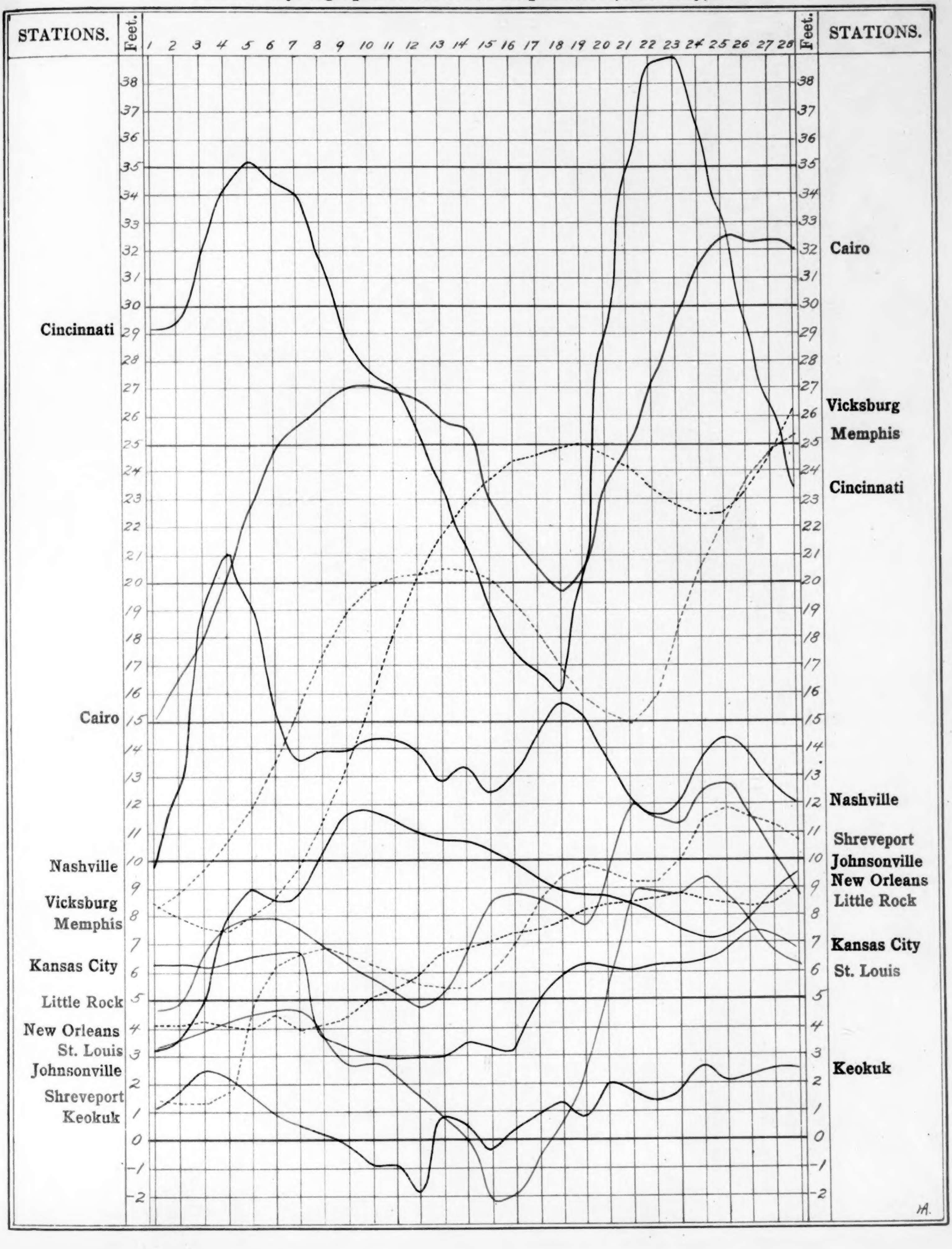

Chart II. Tracks of Centers of High Areas, February, 1914.

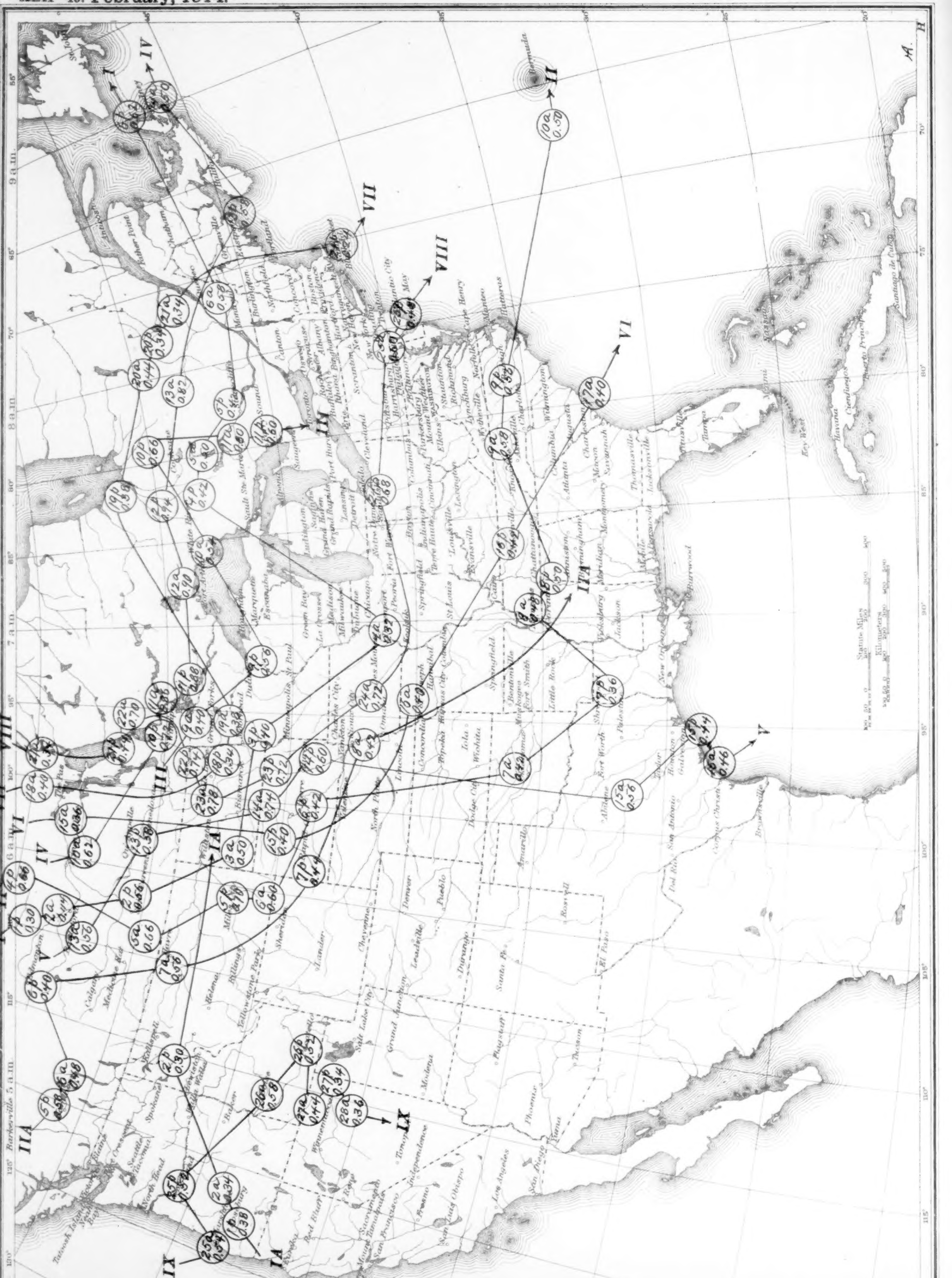

Chart III. Tracks of Centers of Low Areas, February, 1914.

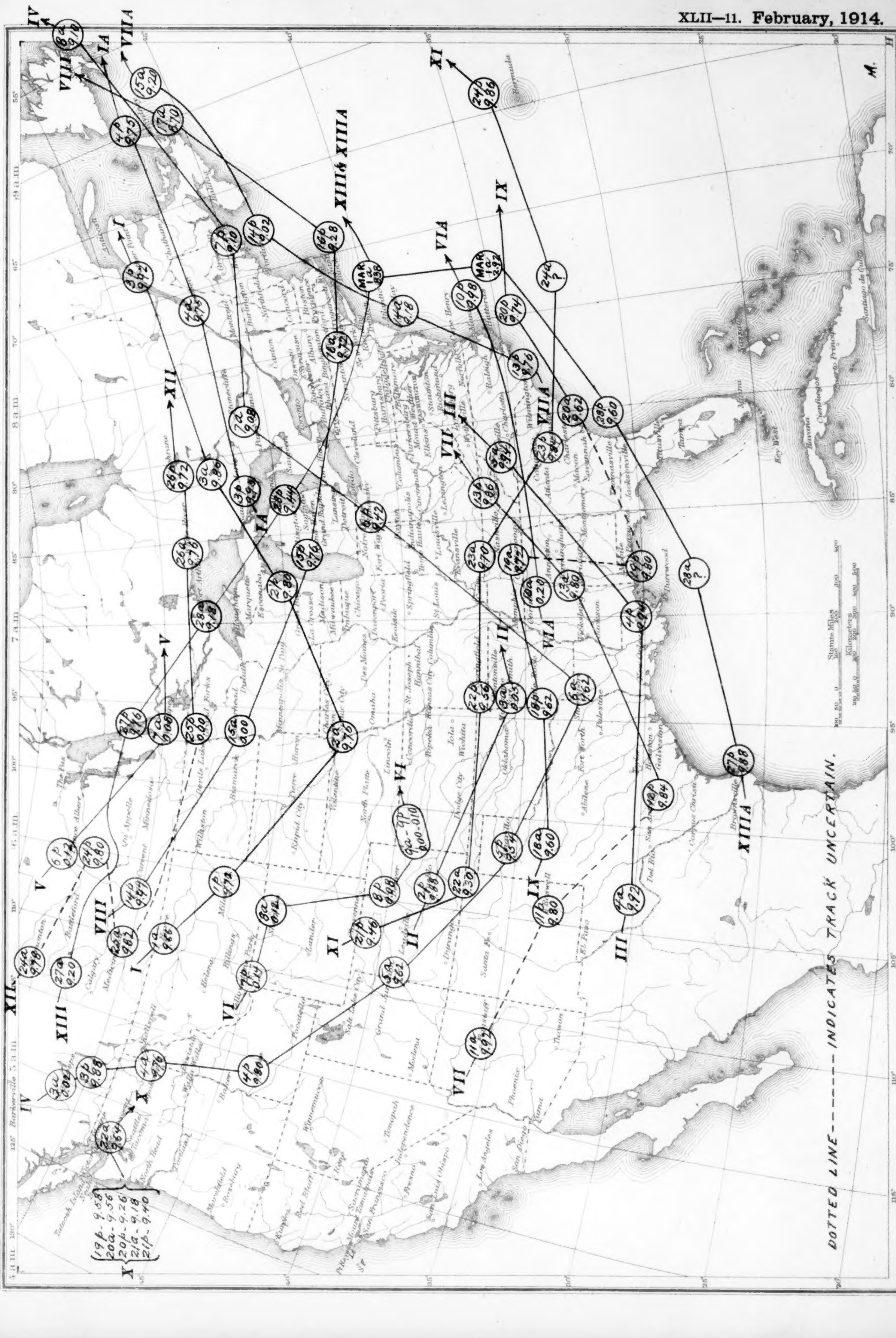

Chart IV. Departure of the Mean Temperature from the Normal, February, 1914.

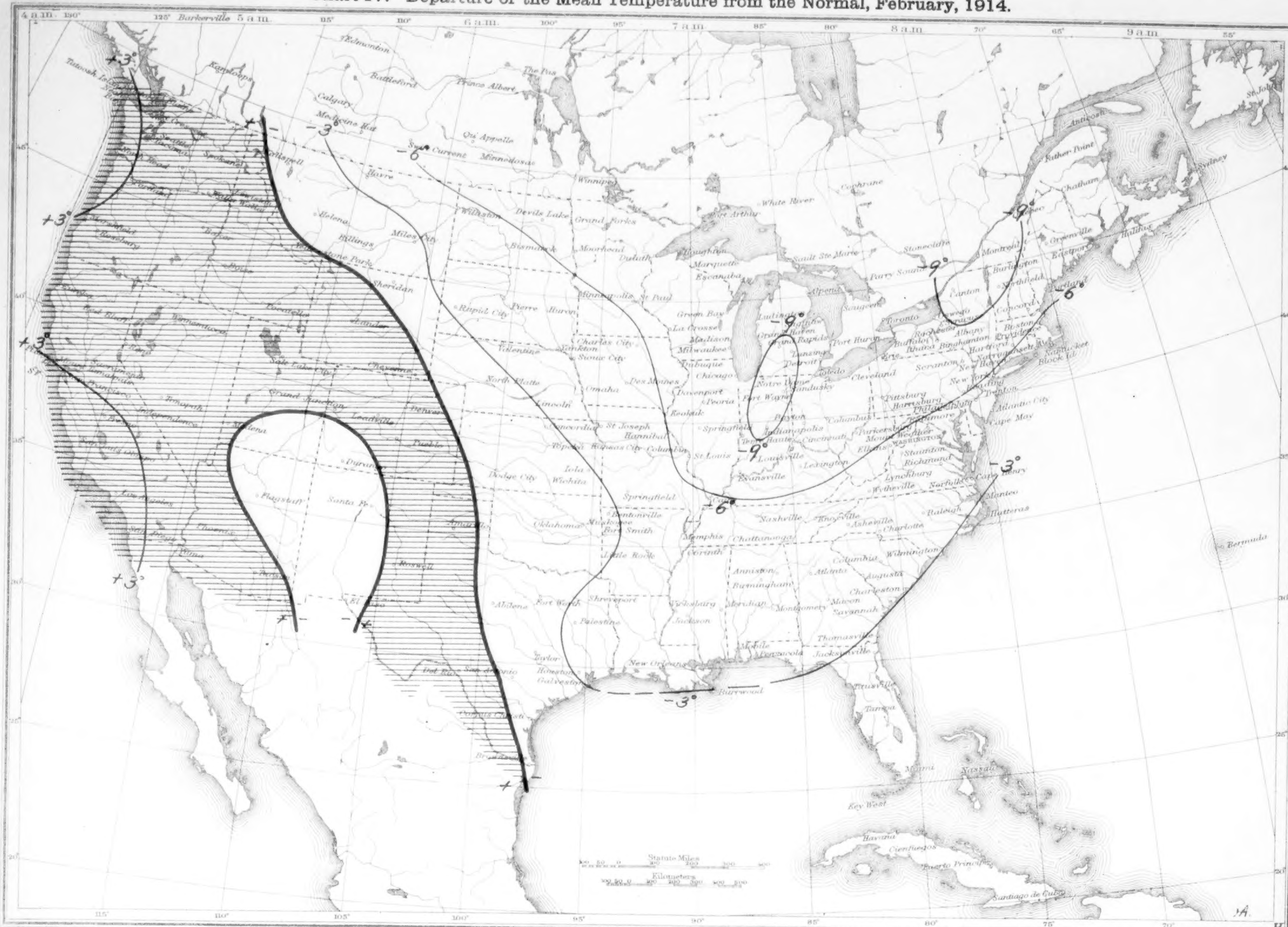

Chart V. Total Precipitation, February, 1914.

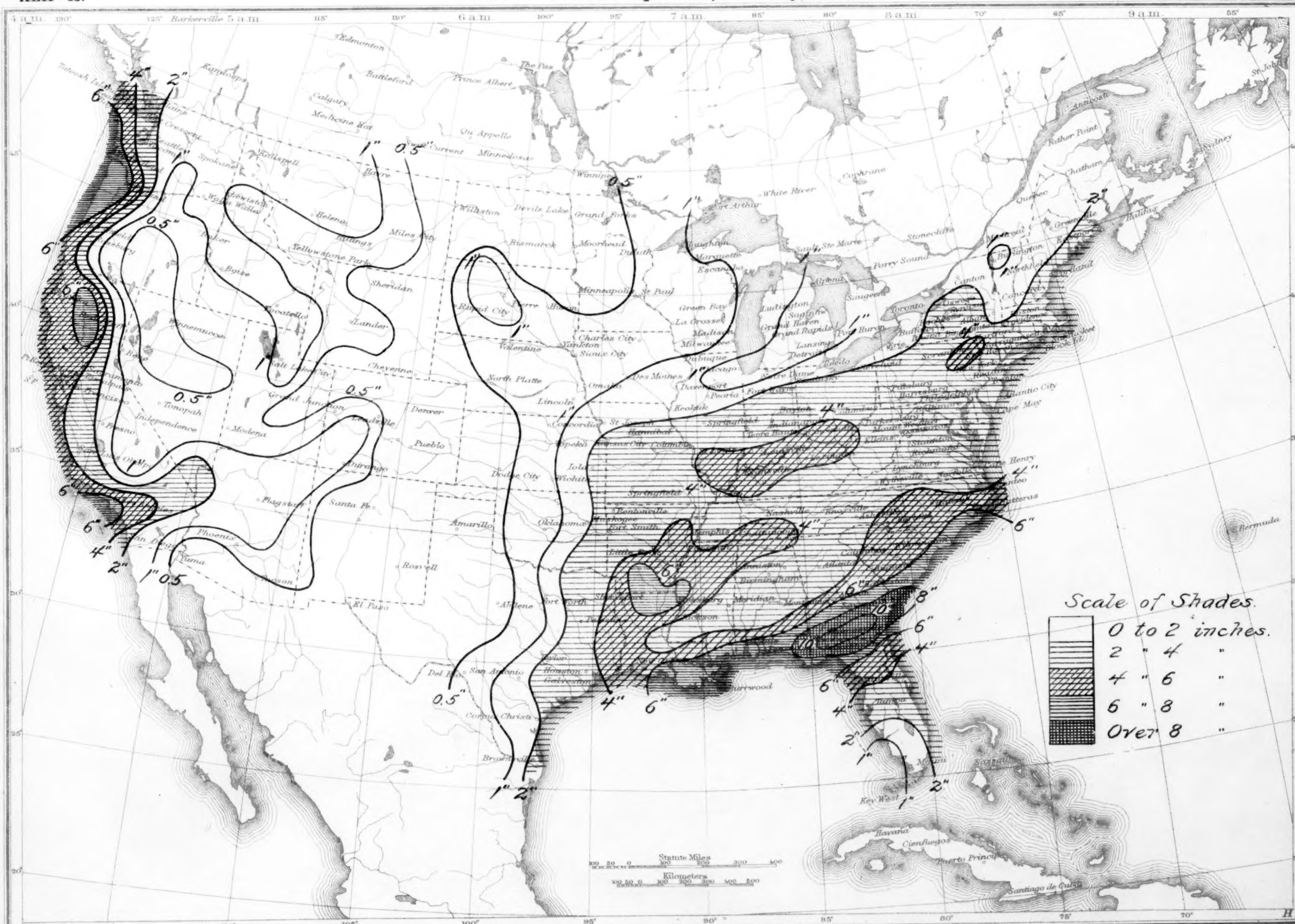

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, February, 1914.

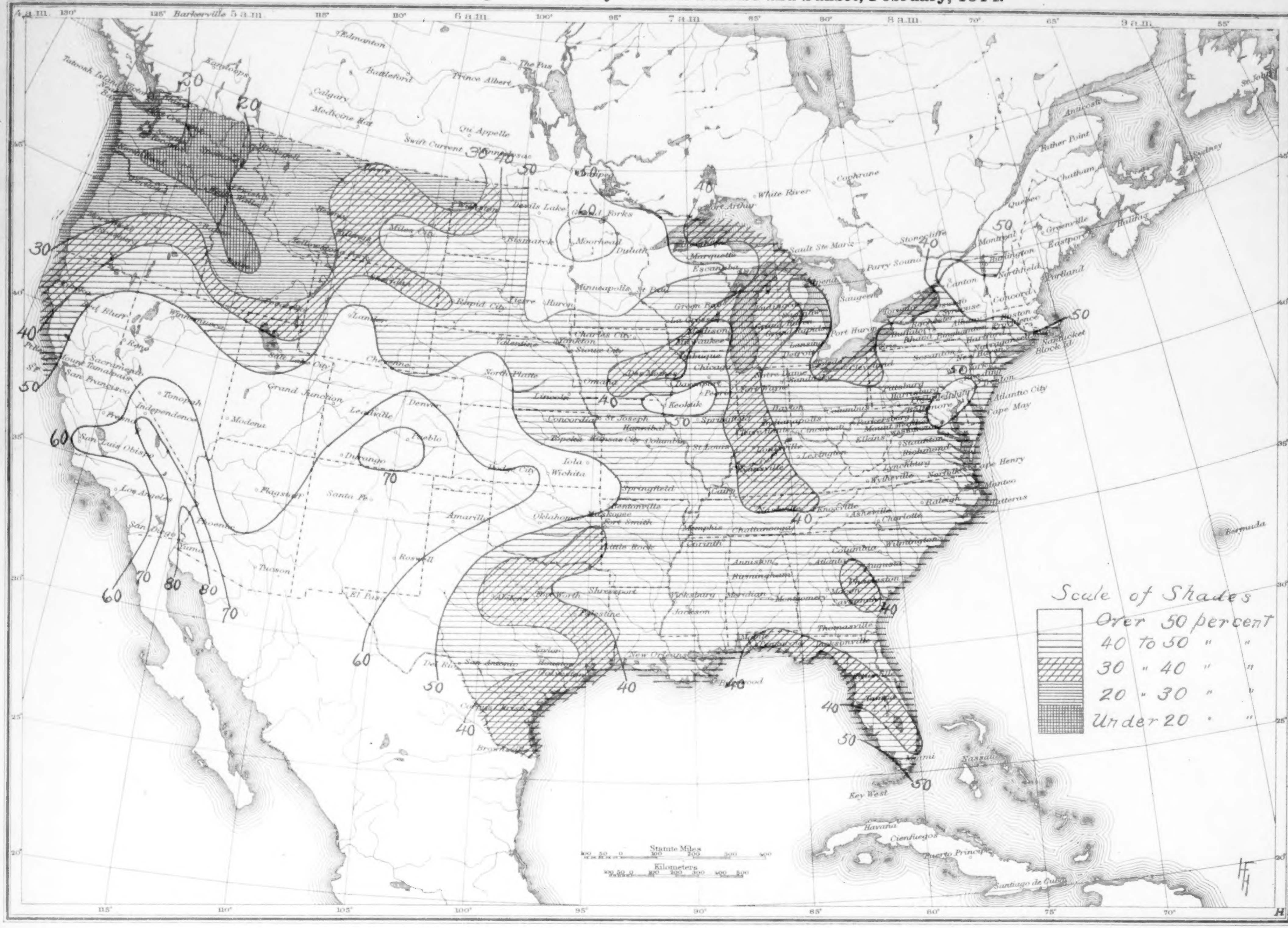

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, February, 1914.

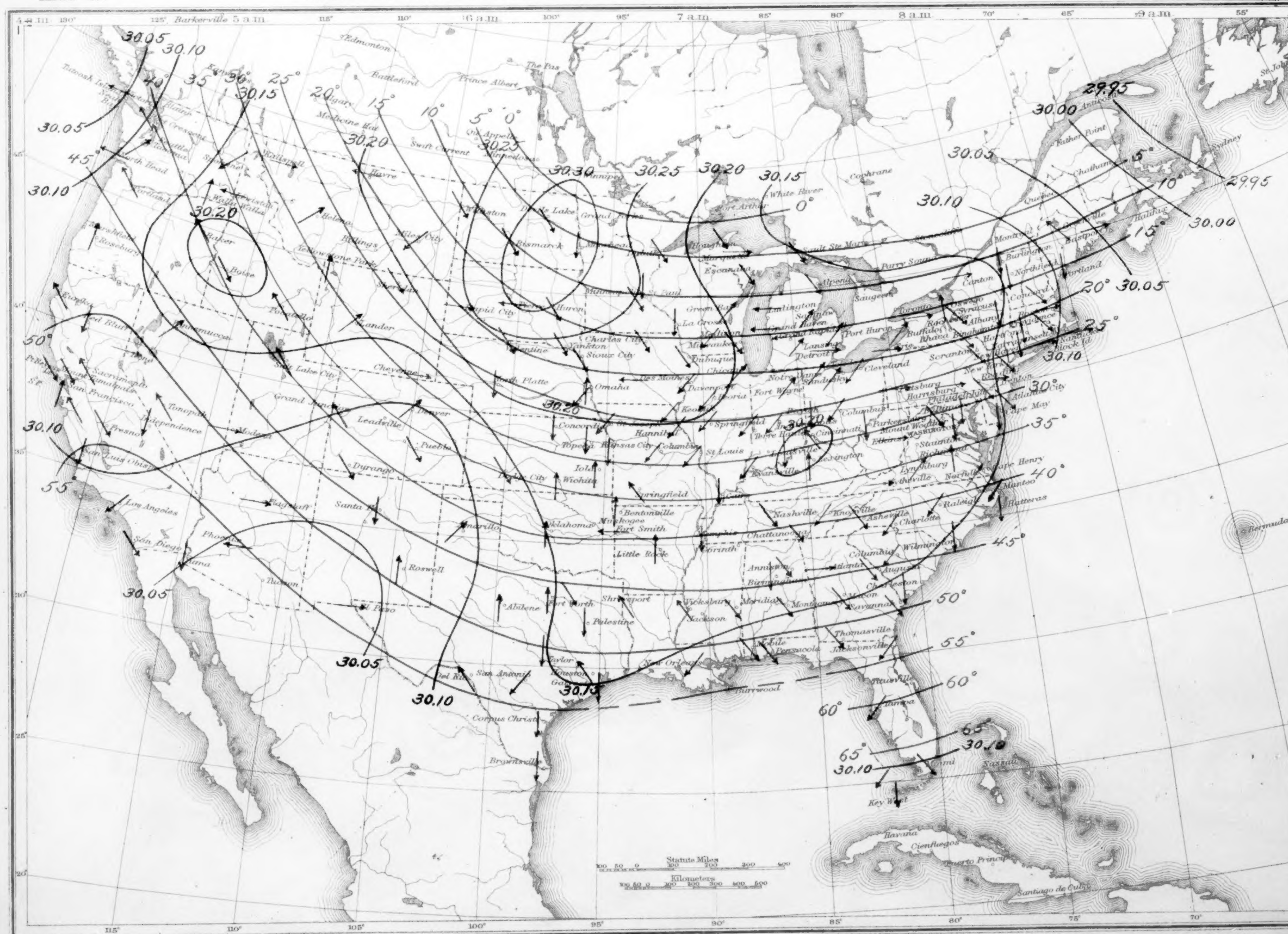

Chart VIII. Total Snowfall, inches, February, 1914.